SENSORY DEPRIVATION

Century Psychology Series

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SENSORY DEPRIVATION: Fifteen years of research

Edited by John P. Zubek
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To Professor D O Hebb and his associates W H Bexton, B K Doane, W Heron, and the late T H Scott, who initiated the first experimental studies on sensory deprivation at McGill University

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To Professor D. O. Hebb and his associates W. H. Bexton, B. K. Doane, W. Heron, and the late T. H. Scott, who initiated the first experimental studies on sensory deprivation at McGill University.

Preface

The purpose of this book is to present a comprehensive and critical review of the extensive research on sensory deprivation which contrary to many predictions that it would be a passing fad has continued to be a thriving area of investigation since the initiation of the McGill University studies in the early 1950 s This persisting and world wide interest has occurred not only because of some of the dramatic effects of sensory deprivation e g hallucinations but also because it has proven to be a useful technique in the study of various topics such as brain function stress personality and motivational theory and applied psychology During the fifteen year period under review research on sensory deprivation has passed through several stages first a series of exploratory studies seeking characteristic phenomena second a stage of greater methodological rigor emphasizing the use of control baselines and more refined measurement techniques and third the current stage of parametric studies appraising the specific role of various variables involved in the complex sensory deprivation situation e g social isolation confinement recumbency and the individual contribution of the various sense modalities Numerous difficult problems however still remain to be investigated The identification of these problems and suggestions for their resolution are among the major objectives of the book

The idea for this book originated in a symposium entitled Sensory deprivation research Where do we go from here? presented at the 1964 annual meeting of the American Psychological Association One answer was that one place to go would be to a thorough consideration of what we knew what we had some guesses about and what remained unexplored With this background the plans for the present book were laid Eight investigators actively engaged in sensory deprivation research were each asked to prepare a thorough and critical review of one or more topics with which they were most conversant or which most appealed to them In order to minimize inaccuracies and insure a comprehensive coverage of the topics each contributor was asked to circulate his first draft to the other contributors for suggestions and criticisms These evaluations together with those of the editor were then forwarded to each author for his consideration in the preparation of the final draft

Although a comprehensive coverage of the material on sensory deprivation has been achieved no attempt has been made to review the

extensive research on such related topics as monotony, effects of early sensory restriction and maternal and cultural deprivation. References to review articles on these topics, however, have been provided in the book.

This volume has been written primarily for the graduate student and the mature investigator. The student will find the book of value in providing him with historical background material for orientation purposes, a familiarity with different sensory deprivation procedures, a broad coverage of experimental findings on a variety of topics, and a description of some theoretical formulations which have been advanced to account for the results. Numerous suggestions for future research are also provided. For the mature investigator, the book will serve as a means of bringing him up to date on a subject which has undergone a spectacular rate of growth particularly during the last ten years. It will also serve as a useful reference work, covering approximately 1,300 references to articles in journals and technical reports, many of which are published in foreign languages. Two bibliographies are provided, one for the literature specifically mentioned in the text, and the other, a supplementary bibliography, listing some articles not cited in any of the chapters (for a variety of reasons), those appearing since the completion of the manuscript, and finally a representative sample of articles on topics indirectly related to sensory deprivation.

I am indebted to the many authors and publishers for their kindness in granting permission to reproduce quotations, tables, and figures from their works. Specific acknowledgments are made in the text. I also wish to express my appreciation to Mrs. Lynne Dobbs and Mr. Louis Bayer for their invaluable assistance in the preparation of the bibliography, typing, and proofreading of the manuscript; to Mr. H. Weiss for the preparation of some of the illustrations, and to the Defence Research Board, Canada (Project 9425-03), National Research Council, Canada (APA 290) and the National Institutes of Health (U.S.P.H.S. Project MH08748), for financial aid covering a part of the clerical work. Finally, I am grateful to my wife, Mary, for her sympathetic understanding through the many months of my preoccupation with this book.

J. P. Z.

Contents

I

Introduction and Methodology

1

Introduction and Historical Background

Peter Suedfeld

About fifteen years have passed since the first appearance of experimental reports describing the effects of sensory deprivation on human behavior. These reports, originating at McGill University in Montreal, Canada, were filled with exciting and unexpected findings. Subjects who had been deprived of patterned sensory input had complicated hallucinations, showed intellectual and perceptual deterioration, became more susceptible to propaganda, and found the situation to be very unpleasant, frequently quitting the experiment in fairly short order.

The publication of these findings evoked interest among biological and behavioral scientists, as well as among many laymen. Here, truly, was a manipulation that made a *difference*—unlike so many pallid experimental situations, a difference you could almost taste. Legions of new participants flocked to the banner: physicians, psychotherapists, physiologists, personality theorists, and psychologists of all persuasions. Suddenly, the McGill results were discussed in every textbook of introductory psychology, in symposia about space flight, in articles concerning brainwashing. As researchers began to gather more knowledge about the new techniques, reviewers noted its links to various other parts of the body of scientific knowledge, and theorists started to integrate the findings into systematic explanations. Ties appeared between more established lines of investigation and the new approach. With continued research and thinking, it has become obvious that these ties are vitally meaningful and that a greater integration of related approaches in many areas is necessary for the adequate understanding of any one approach.

SENSORY DEPRIVATION: HISTORICAL ROOTS

Some of these related interests were first pursued decades before the McGill work, and thus can be considered historical roots even though they

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are still lively and active research areas Some major points of origin were studies of the effects of long term sensory and/or social deprivation during development and reports of relatively brief deprivation with adult organisms The first of these dealt mostly with experimental treatments of infrahuman species while the latter typically involved human beings who were isolated in natural situations Among other sources of impetus were interest in exploratory activity (see chapter 6) neurophysiological advances (particularly the discovery of the reticular system) applied work on boredom and vigilance and the increasing popularity of theories of activation and arousal (see e g Fiske & Maddi 1961b)

One way to identify the conceptual ancestors and relatives of experimental sensory deprivation is to analyze its significant features each of which turns out to be the main focus of other lines of investigation These main characteristics include the reduction of stimulus input levels the reduction of stimulus variability social isolation and confinement The relevant work is of three major types experimental work with infrahuman species experimental work with human beings and observational—including self-observational—reports from real life situations

Reduced Levels of Stimulation

The reviews of Beach and Jaynes (1954) Riesen (1961a 1966) and Thompson and Schaefer (1961) summarize experimental findings on the effects of stimulus reduction It has been established that animals deprived of some input modality (e g vision) during development may suffer physiological damage If the deprivation lasts long enough this damage may become irreversible Deprivation can also lead to behavioral decrements particularly in perception and perceptual learning (see especially Riesen 1961a and 1966) The motivational characteristics of stimulation have been demonstrated by researchers whose animals were first deprived of sensory input which was then used as a reinforcer in operant conditioning paradigms (e g one series of studies by Butler and his co-workers beginning in 1953 and one by Fox and others beginning in 1962)

On the human level there are few such studies before the appearance of the McGill experiments Von Senden (1932) described the perceptual problems of individuals whose congenital cataracts were removed and some researchers have drawn attention to the social and cognitive decrements accompanying deafness and blindness (e g Myklebust 1960 Klein 1962)

Reduced Stimulus Variability

Since the normal laboratory colony provides an environment which is low in variability we may consider enrichment studies in this category that is we can view the enriched environment group as a control group which encounters a more varied environment than the experimen

tal" group reared or kept in the usual cage situation. The study of the effects of enriched environments indicates the importance of stimulation in the development of young organisms. Copious work on gentling and handling has shown that these treatments in early life have generally beneficial effects upon the adult animal's resistance to food deprivation (Weininger, 1953), water deprivation (Levine, 1957), and a variety of other stressors (Newton & Heimstra, 1960; Weininger, 1956; Ader, 1959). Behaviorally, gentled animals show less emotionality in novel environments (e.g., Ader, 1957, 1959; Levine, 1959; Levine, Chevalier, & Korchin, 1956). Superior performance on learning tasks was shown by gentled subjects in discrimination problems (Bernstein, 1952) as well as in escape and avoidance learning (Barry, 1957; Levine, Chevalier, & Korchin, 1956). Handled animals have also been demonstrated to be dominant in situations involving social competition (Levine, 1959; Rosen, 1958), in contradistinction to the submissive restricted animals of Melzack (1963) and King and Gurney (1954).

Similar beneficial effects have been ascribed to moderate thermal stress (King & Connon, 1955; Newton & Heimstra, 1960), being repeatedly thrown in the air (Ader, 1959), and low-intensity electric shock (Denenberg & Bell, 1960; Mogenson & Ehrlich, 1958). Animals reared in environments richer in manipulable objects and varying structures than the standard laboratory cage have also been shown to be superior in maze-learning ability (Forgays & Forgays, 1952; Bingham & Griffiths, 1952; Hymovitch, 1952).

The effects of restricted environments during human childhood have, of necessity, been less extensively investigated. Dennis and Dennis (1951) stand alone in even approximating deliberate definition of the parameters of restriction. These researchers greatly reduced the normal amount of social interaction and the availability of manipulable objects (e.g., toys) in rearing twin girls until the age of 13 months. The children were found to be abnormally slow in developing some complex motor activities: sitting alone, standing with support, and visually directed reaching and grasping. These deficiencies were not due to muscular weakness or lack of exercise, since diffuse motor activity was almost continuous when the children were awake.

Spitz (1945, 1946a, and 1946b), Goldfarb (1955), and Dennis (1960) have discussed the effects of institutionalization on children. Generally, individuals whose infancy was spent in the institutional environment, which is relatively poor in both social contacts and in variability of physical surroundings, have shown signs of low intelligence and abnormal passivity and dependence.

The well-known work of J. McV. Hunt (e.g., 1961, which provides a fine review) has pointed out the importance of environmental stimulation in the development of intelligence. Hunt's research is perhaps the best

example of the application of this concept to vital real life problems and has demonstrated to workers in many areas of educational and developmental psychology the necessity for sufficient stimulus variability in childhood

Social Isolation

Isolation has often been shown to have effects similar to those of sensory stimulus reduction Beach and Jaynes (1954) and Melzack (1963) have shown the inappropriate sexual behavior of insects, birds, rats, and dogs which had been reared in isolation these responses include immature sex play, failure to respond to the call of other members of the species, and inability to discriminate (though not to perceive) sexually relevant cues Rearing animals in isolation also makes them less viable when stressed (King & Connon 1955) and such animals often display the diffuse, random activity which has been noted in subjects reared in sensorially restrictive environments (Beach & Jaynes 1954) They are less gregarious than animals reared in communal cages (Beach & Jaynes, 1954) and are more disturbed and submissive in competitive situations (Scott, 1950, King & Gurney, 1954) The intensive work of Harlow (e g , Harlow & Harlow, 1962) is perhaps the best known and certainly the best written account of these effects A recent study (Lessac, 1966) has demonstrated for the first time that isolation during the early developmental period not only prevents the normal manifestation of various behavioral processes, but also actually destroys already developed abilities Lessac interprets these results as indicating that the organism s inhibitory processes have become adapted to low intensity, low variation input and lose their capacity to block the high level of stimulation which the animal encounters upon release from isolation

Temporarily isolated animals have also given evidence of behavioral and emotional disturbances (Köhler, 1927, Nissen, 1951) Further, it has been demonstrated that animals undergoing a stressful approach avoidance conflict situation develop gastric ulcers more rapidly if they experience this situation alone than if they are with others (Conger, Sawrey, & Turrell 1956 1958 Sawrey & Weisz, 1956) Mason (1960) has shown that when faced with an emotionally disturbing stimulus, monkeys become less emotional in the presence of another monkey—even an unfamiliar one Davitz and Mason (1955) have reported a similar reduction of open field fear responses in rats when an unafraid rat was also present

Goldfarb (1955) has described the personality of children who had spent their first year of life in almost complete isolation and their second and third in a restricted institutional setting these children when compared to a control group of similar family origin but reared with foster families were less intelligent had lower conceptual ability (giving more concrete responses on categorization tasks) and showed signs of intellectual and emotional impoverishment They were passive and apathetic

but at the same time hyperactive and restless They showed little affection for others (cf the lack of gregariousness and withdrawal from social stimuli of chicks and ducks reared in isolation—Beach and Jaynes, 1954) Isolation and confinement of "unwanted" children has been shown to have similar deleterious cognitive and emotional results (Davis, 1940, 1947) The work most purely concerned with social deprivation in children, that dealing with lack of mother child interaction, will not be considered in detail here, since it concerns the importance of only one specific source of social stimulation, but the results of such deprivation are comparable to those following general social or sensory stimulus restriction (Ribble, 1943 1944, Foss, 1961) The behavior of autistic and feral children also seems to be related to these kinds of deprivation (Gewirtz 1961, Bettelheim, 1959), and it is interesting to note that the response of autistic children to painful stimulation (Kanner & Eisenberg 1955) closely resembles the unadaptive responses of restricted dogs (e g Melzack, 1963) Another similarity is the inability of restricted children (Goldfarb 1955) as well as of dogs (Thompson & Heron, 1954), to inhibit or delay responses Isolation in childhood has also been mentioned as a causative factor in alalia (Kainz, 1960) and apparent mental deficiency (Kratter, 1959)

Isolation without reduction of the amount of patterned or total stimulation also has disturbing effects on human adults The most dramatic literature here is anecdotal (see Leiderman & Stern 1961) dealing with the experiences of shipwrecked sailors, prisoners in solitary confinement, explorers alone in the Arctic and Antarctic, and individuals accomplishing long journeys in one-man boats or aircraft Generally, the effects of such experiences include disturbances in attention and in organization of thought, labile and extreme affect, hallucinations and delusions, etc, all of which are similar to those reported by subjects in sensory deprivation experiments (see Kubzansky, 1961b) Bovard (1959) in reviewing the literature concerned with isolation and stress in human beings came to the conclusion that both children and adults responded more adaptively to stressful situations when they were with others than when they were alone

Confinement

It is difficult to say much about the effects of confinement *per se* Most of the work on input reduction, variability reduction, and isolation also involves some degree of physical confinement or motor restriction, so that what we may call response deprivation is an integral part of sensory/social deprivation This is particularly true of the reports concerning the experiences of human subjects, with lower animals more nearly pure restriction has sometimes occurred

Restriction of the activity of the limbs during early life has resulted in abnormal postural and motor behavior in adult animals (Nissen, Chow, & Semmes 1951) The work of Clarke, Heron Featherstonehaugh, Forays

and Hebb (1951) and of Melzack and his associates (Melzack 1954 1963 Melzack & Scott 1957) has demonstrated the unadaptiveness of the responses emitted by dogs reared in restricting cages when they come into contact with novel stimuli Response to pain for example even when the animal clearly indicates that the stimulation has been perceived does not take the form of successful escape or avoidance More striking perhaps is the extremely high level of excitement (freezing followed by rapid highly active but apparently random exploration) evidenced by these dogs when they are first permitted to enter a new environment (Melzack 1963) and the similar behavior of restricted rats upon being introduced into a maze (Woods Ruckelshaus & Bowling 1960)

A concomitant behavioral result of restricted rearing is impaired learning ability Rats reared in small cages have been found to perform at an inferior level on maze problems (Bingham & Griffiths 1952 Hymovitch 1952 Forgays & Forgays 1952) Irrelevant response patterns in a discrimination situation fail to be inhibited while there is generally greater difficulty in learning visual discriminations (Melzack 1963) 'Restricted dogs also fail to attend selectively to innocuous but threatening visual and auditory stimuli (Melzack 1963)

There were also three practical problems which had a role in the interest generated by sensory deprivation One was the performance decrement of individuals performing low variability tasks for long periods of time (e g radar operators truck drivers for a fine review see Fiske 1961) Another was the problem of getting along' in isolated groups such as nuclear submarine (and later spacecraft) crews fallout shelter confinees and polar station personnel—in Haythorn and Altman s (1966) elegant phrase people who are alone together see chapter 11 of this volume The third was the public excitement over the so-called brainwashing technique used by the Chinese before and especially during the Korean War which reportedly involved sensory-deprivation like experiences (see e g., Schein 1961 Lifton 1961 and chapter 5 of this volume)

CENTERS OF SENSORY DEPRIVATION RESEARCH 1

and programs which have contributed significant new data techniques or theories I apologize to those who were omitted either because of space limitations or because of my own misevaluation—or ignorance particularly in the case of foreign researchers—of their work

1 McGill University (Montreal) The group which in 1951 developed the experimental sensory deprivation technique (in their case homogeneous light and sound see Figure 2-1) was directed by Professor D O Hebb While the immediate stimulus for the research was an interest in Russian and Chinese "brainwashing" measures were taken of intellectual perceptual affective motor and electroencephalographic as well as attitudinal changes The results widely and rapidly disseminated led to important modifications in motivational and neurophysiological theory —including Hebb's own—in establishing the active as well as reactive tendencies of human beings The students who conducted and reported the research (Hebb's name appears only on technical and theoretical reports, not on the published research papers) were Woodburn Heron now pursuing related lines of research at MacMaster University W H Bexton B K Doane W Mahatoo and the late T H Scott It is the work of these men that lent the original momentum to the research conducted by so many others and that remains even now the most generally known part of the literature The program ended in 1951

2 Princeton University (Princeton New Jersey) Jack A Vernon a physiological psychologist was prompted by the curiosity of an undergraduate student to set up the first darkness-silence sensory-deprivation program in 1955 He and a succession of graduate students went on to investigate physiological sensory perceptual motor cognitive motivational and attitude effects Among other findings this research program established the importance of exact definitions and classifications in the study of hallucinations and reported the first instance of intellectual improvement as a result of sensory deprivation The program was terminated in 1964 Members of the group who contributed to the output of the laboratory were John Hoffman (the undergraduate who started it all) D K Candland W L Gulick Harold Schiffman T A Marton T E McGill E A Peterson K M Goldstein R J Grissom and Peter Suedfeld the last two of whom in turn have established sensory-deprivation laboratories elsewhere

3 National Institute of Mental Health (Bethesda Maryland) In 1955–56 John C Lilly (a psychiatrist now famous for his research on the dolphin) invented the water immersion technique of sensory deprivation While its great demands on facilities have prevented the technique from becoming widely used its dramatic nature has had some impact on popular fiction (e g Deighton's *The Ipcress File* 1962) Lilly used it to produce one of the most detailed descriptions of the subjective experiences of a deprived individual and originated the concept of stimulus action

hunger which is now widely used by sensory-deprivation theorists Jay T Shurley, one of Lilly s associates, has gone on to establish his own laboratory (see paragraph 15 in this list)

4 *Boston City Hospital and Harvard Medical School* A mixed group of psychologists and psychiatrists including J M Davis, S J Freedman H U Greenbaum Milton Greenblatt P E Kubzansky, P H Leiderman, W F McCourt, J H Mendelson and Donald Wexler, and headed by Philip Solomon carried out a long series of studies using respirator confinement as well as more conventional techniques (see Figure 2–5) Like most researchers in the field this group has investigated a great variety of sensory-deprivation phenomena and has also produced some good reviews (notably Kubzansky, 1961b) Perhaps the best known product of the group was the symposium volume, *Sensory Deprivation* (Solomon et al 1961, the symposium having been held in 1958), which was the first book length publication in the field More recently, A Michael Rossi and Solomon have conducted a number of studies in which they reinforced an operant response by early release from sensory deprivation, and Rossi particularly has been active in some of the theoretical controversies now developing among researchers

5 *Duke University (Durham, North Carolina)* Researchers at the Duke Medical Center have included S I Cohen Bernard Bressler, A J Silverman and Barry Shmavonian—again a group composed of both psychologists and psychiatrists The laboratory has produced an early—and good—analysis of the variables relevant to sensory deprivation studies (Cohen Silverman, Bressler, & Shmavonian, 1961) some interesting work on physiological effects conceiving of sensory deprivation as one of a class of stress situations and a persistent attempt to consider individual differences in the response to deprivation using an experimentally as well as theoretically well-established personality variable (field dependence independence)

6 *Human Resources Research Office (Monterey, California)* The HumRRO group headed by Thomas I Myers included Seward Smith and D B Murphy as his principal collaborators Beginning with military backing and Myers interest in motivation these psychologists turned out admirable research from the very onset of the program in 1956 Possessors of the best equipped laboratory of them all (see Figure 2–2) they made significant contributions to the study of the effects of sensory deprivation on hallucinations attitude change emotions motor behavior, and cognition Perhaps their most important work has been in the area of the measurement of affect and subjective stress with the development of indices such as the mood adjective check list the subjective stress scale and mechanical measures of restlessness Unfortunately the group did not disseminate its findings in the usual journals restricting itself to presented papers and a great number of technical reports The last report (Myers, Murphy Smith & Goffard 1966) is a book length summary of the work,

which should be in the library of everyone who is interested in this area Myers and Smith are currently engaged in similar research at the Naval Medical Research Institute Bethesda Maryland

7 University of Manitoba John P Zubek one of Hebb s former colleagues at McGill University has since 1959 carried on the Canadian work in sensory deprivation which Hebb left in 1954 With a number of graduate students technicians and consultants Zubek has used deprivation of unusually long durations (7 to 14 days) and varying modalities with many dependent variable measures to produce approximately 30 publications to date His major interest is in the neurophysiological mechanisms involved and the laboratory at the University of Manitoba Winnipeg Canada is known for its unique physical design (a large translucent plexiglas dome suggested by an aircraft canopy cover see Figure 2–3) as well as for its detailed parametric studies

8 University of Michigan (Ann Arbor) A psychiatrist John C Pollard was motivated by the 1958 Harvard Symposium to initiate a series of studies at Michigan s Mental Health Research Center (see Figure 2–8) Using female subjects in quantity for the first time he attempted to establish baselines for behavior in sensory deprivation and to compare these stress responses with the behavioral effects of various psychoactive drugs After several studies of this nature and the first experiment comparing the effects of repeated deprivation sessions the group became best known for its emphasis on the importance of suggestion and expectancy in producing pseudo-sensory-deprivation phenomena These later writings have been a focus of theoretical controversy ever since Besides Pollard the major figures in this laboratory were a computer scientist Leonard Uhr and a clinical psychologist C W Jackson Jr who is currently head of another sensory deprivation laboratory (see paragraph 16 in this list)

9 New York University At N Y U s Research Center for Mental Health Robert R Holt and Leo Goldberger teamed up to produce a small quantity of highly influential research which Goldberger is still continuing (see Figure 2–6) These investigators were the first to attempt a systematic study of personality variables as they affect the response to confinement using divergent types of subjects (e g actors vs college students) Rorschach testing etc They also identified what may be the crucial factor determining cognitive effects the complexity of the tasks to be performed a quality not considered by previous researchers

10 Albert Einstein Medical Center (Philadelphia) This name is applied to a series of experiments directed since 1958 by Marvin Zuckerman successively at Indiana University Medical Center Brooklyn College Adelphi University and currently at the Albert Einstein Medical Center Moving from tank respirators to room confinement Zuckerman has produced parametric studies (notably studies in which sensory deprivation social isolation and physical confinement were not confounded) biochemical assays and some of the best critical reviews extant His team also

developed the Affect Adjective Checklist and the Sensation Seeking Scale both widely adopted elsewhere Besides his long term collaborator D V Biase and other coauthors (Harold Persky the biochemist and students such as Nathen Cohen Eileen Brockman Sheldon Levine Merry Haber and Angela Podkameni) Dr Zuckerman specifically requested that credit be given to his long suffering monitors and data analysts T R Hopkins and Katherine Link—whom he calls the unsuing (*sic*) heroes of sensory deprivation research (Zuckerman 1967 personal communication)

11 Allan Memorial Hospital (Montreal) A group of psychiatrists headed by the late Hassan Azima and including his wife Fern Cramer Azima and Paul Vispo were the first to use sensory deprivation as a therapeutic tool In a brief research program they investigated the possibilities of anaclitic therapy using the technique to develop a relationship between the patient and the therapist based on the model of the mother infant relationship (Azima Vispo & Cramer Azima 1961, p 144)

12 Richmond (Virginia) V A Hospital H B Adams R N Carrera G D Cooper R G Gibby M H Robertson and H R Tobey a group of clinical psychologists in Richmond carried out between 1958 and 1963 a series of studies on the improvement of the self image of psychiatric patients who underwent sensory deprivation and heard appropriate messages This research probably the most closely related of all to brainwashing is reviewed in chapter 5

13 Los Angeles, California Eugene Ziskind a psychiatrist in private practice responded to a paper read by Hebb before the American Psychiatric Association in 1954 by investigating the possibility of setting up a sensory deprivation laboratory to study the induction of hallucinations and delusions Abandoning this attempt he instead produced the most systematic and useful observations of clinical sensory deprivation i e the effects of post-eye surgery patching (see chapter 10) His studies of the "hypnoid syndrome and of visual imagery deserve more attention from researchers than they have received

technique (see Figure 2–9) Using multisubject experiments and quantitative measures he is making it possible validly to compare the effects of this method with those of other sensory deprivation situations

16 Case Western Reserve University (Cleveland, Ohio) At the Frances Payne Bolton School of Nursing C W Jackson Jr (see paragraph 8) is collaborating with several nurse psychologists (Rozella Schlotfeldt Rosemary Ellis and Rosemary Rich) on studies of confined and/or sensorially deprived patients recovering from eye surgery or heart surgery (see chapter 10) Their major interest is in refining the existing indices of subjective experiences

17 Rutgers—The State University (New Brunswick New Jersey) Peter Suedfeld (see paragraph 2) is pursuing a course of studies on the cognitive effects of sensory deprivation its relevance to changes in persuasibility and the importance of personality and birth-order factors (see chapter 5)

18 University of Bologna (Italy) Professor R Canestrari is directing a program of research on the sensory and perceptual motor effects of sensory deprivation Although several articles have been published all in Italian his work is unknown to most investigators in this area

19 Tohoku University (Sendai, Japan) A great number of studies investigating many different phases of sensory deprivation have been carried out by a large team of Japanese psychologists (including T Hariu H Ueno T Kato S Saito Y Ohkubo O Kokubun M Ohyama and T Okuma) headed by Professor S Kitamura Because their papers are published in the *Tohoku Psychologica Folia* not widely available here their work on hallucinations cognition and physiological effects has lacked influence

20 Psychiatric Research Institute (Prague) Two psychiatrists Jan Gross and Ludvik Sváb followed Azima s (see paragraph 11 of this list) lead to study anaclitic therapy To date they have presented several papers at international conferences and produced an excellent bibliography in two editions

Other researchers have operated in Great Britain the Netherlands and the USSR to say nothing of the many North American workers whom I have not mentioned I want to reemphasize that I have selected those laboratories which (1) were among the early pioneers (2) had relatively long life spans and/or (3) produced much research on particularly influential ideas

REVIEWS OF THE LITERATURE

A good review can be an invaluable aid not only to interested people outside a field but perhaps even more to those most intimately involved One can obtain a coherent view of the state of the art recognize previously

overlooked problems—or, more rarely, solutions—and, best of all, gather leads for further progress in research and therapy

It has been difficult to review the sensory deprivation literature For one thing it is tremendously diffuse, for another, it has been growing by leaps and bounds—the researchers keep getting ahead of the reviewers The fact that workers from so many different backgrounds are involved calls for a review by either a Renaissance like master of all trades, or by an equally diverse group

Early reviews tended to focus on identifying problems and relevant variables This essentially, was the contribution of most of the chapters in Solomon et al (1961), the volume produced from the 1958 Harvard Symposium Solomon also published a useful review in 1957, and in 1959, Wheaton attempted to identify the generalities found by researchers in the area and to compare these with reports of similar "real life" situations An anonymous review appeared in *Lancet* in 1959, and since then many English language and foreign language journals have carried similar reviews (e g , Brownfield, 1964, Kenna, 1962, Okuma, 1962, Svorad, 1960, Zubek, 1964c Zubek, 1968b) Chapters about sensory deprivation have appeared in books as diverse in focus as *Functions of Varied Experience* (Fiske, 1961) *The Manipulation of Human Behavior* (Kubzansky, 1961b), *Hallucinations* (several chapters in West, 1962a), *Personality Change* (Haggard, 1964), *Recent Advances in Biological Psychiatry* (chapters in Wortis 1964), *Psychological Aspects of Space Flight* (Flaherty, 1961), and *Progress in Physiological Psychology* (Riesen, 1966)

Among book length treatments of the field, other than the Harvard Symposium book, Brownfield (1965) attempts to discuss not only experimental sensory deprivation, but also brainwashing and other related topics Necessarily, coverage is broad but shallow, the book provides a fairly good bibliography of relevant studies Schultz s *Sensory Restriction* (1965) is a narrower and deeper treatment, reviewing more of the literature and adding a theoretical framework which is used to synthesize some of the findings Vernon's *Inside the Black Room* (1963) is a discussion primarily of the Princeton program aimed at a nonprofessional audience and thus lacks references, statistics, and details, but is high in readability

Desafférentation Expérimentale et Clinique (de Ajuriaguerra, 1965) is the only foreign language book in the field, and contains chapters mostly by foreign workers concerning the effects of sensory deprivation on various behavioral processes

Among bibliographies two are the most up-to-date and the most comprehensive, and deserve special mention One is a mimeographed series now including over 800 references, collected by Zubek, Dobbs and Bayer (1967) Papers are listed alphabetically by author The bibliography concentrates on experimental work, and its mimeographed format has the advantage of timeliness appendices are easy to add The second is com

piled by L. Sváb and J. Gross and its second edition (1966) appears in paperback book form. Its 1,500 entries are grouped under categories (e.g. "Social Isolation and Sensory Deprivation by Detention") which quite thoroughly cover not only experimental but also clinical and various field approaches. The usefulness of this excellent work is limited only by the difficulty of producing new editions and by its relative lack of availability.

OUTLINE OF THE BOOK

Part I of the book consists of a general familiarization with the background and basic problems of the area: this introduction and a chapter on considerations of methodology and definition. Part II, the core of the book, contains nine chapters. Each of these discusses, interprets, and synthesizes the findings in one of the major areas of concern: a description of several variables which can affect deprivation results, hallucinations in various sensory modalities, cognitive and attitudinal changes, the motivational characteristics of deprivation, effects on perceptual and motor processes, physiological and biochemical findings, and individual differences in tolerance for deprivation and the attempts which have been made to predict isolation tolerance. The last two chapters of Part II deal with two closely related lines of interest: studies of clinical sensory deprivation employing eye surgery patients, and investigations of small groups in confinement. Finally, Part III, instead of the usual summary, presents a discussion of the theories which either have implications for sensory deprivation or which were specifically designed to explain and/or predict sensory deprivation results.

2

General Methodological Considerations

A. Michael Rossi

Sensory deprivation research has increased logarithmically over the past dozen years and this vigorous upsurge of research has continued to yield a conglomeration of data which include apparently contradictory results and interpretations. This state of affairs has led to a frequently posed question: How many of the reported effects of sensory deprivation are just artifacts due to methodological limitations? Unfortunately a definitive answer to the question is not yet available. It is true that there are enough trends and consistencies in the body of data (discussed fully in ensuing chapters) to give strong support to the validity of most of the reported sensory deprivation effects. However, it is equally true that this field of research is plagued by methodological problems which are complex and not yet fully resolved.

Basic Methodological Dilemma

The primary affliction is better labeled a methodological dilemma rather than a methodological problem. The dilemma (inherent in all new fields of inquiry) is how to carry out research in which all important variables except those under investigation are controlled when research must be carried out to identify which variables are important. Faced with this dilemma investigators commonly resort to "exploratory research" to make tentative estimations of the effects of different variables. The strategy is to make successive refinements in succeeding research leading to eventual identification and exemplification of important variables. This "zeroing in" process is logically sound but it proceeds much more smoothly in theory than in practice. One hindrance is that the need for closure seems to be as great in scientists as it is in laymen and results of exploratory research are often given greater significance than is either intended by the original investigator or warranted by the design of the research. Because

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much of the available data in this field have been collected in exploratory studies, the inconsistencies and apparent contradictions in the results are to be expected

Definitions

Another problem commonly found in most new fields of research is the absence of a standard terminology Imprecise and heterogeneous terms are coined by different investigators and such terms seriously interfere with attempts to relate and integrate data obtained in different laboratories The extent to which ambiguous terms plague this area of research will become evident to the reader after perusing the remaining chapters in this book It will be seen that hardly any facet of this research is uncontaminated by this impediment to communication and clear understanding

There is no unequivocal term to describe the field of research itself The term used in the title of this book is Sensory Deprivation but the research discussed herein has been described by the original investigators by a variety of other terms An indication of the variety can be gleaned from a perusal of the following list of terms used more or less synonymously in the research literature (compiled by Brownfield, 1965)

1 sensory deprivation
2 perceptual deprivation
3 social deprivation
4 stimulus deprivation
5 sensory isolation
6 perceptual isolation
7 social isolation
8 stimulus isolation
9 sensory limitation
10 social limitation
11 sensory reduction
12 stimulus reduction
13 environmental stimulus reduction
14 decrease in sensory variability
15 restricted stimulation
16 controlled sensory input
17 reduced sensory stimulation
18 reduced sensory input
19 sensory alteration
20 Ganzfeld
21 homogeneous stimulation
22 solitude
23 confinement
24 isolation
25 invariant input

None of these terms, as defined in a dictionary, adequately describes the majority of experimental conditions that have been employed in this area of research It is doubtful that such a term exists at the present time—even a complicated one such as Experimental interference with sensory and motor function and with interpersonal communication (Miller, 1962) is inadequate Probably agreement on terms will be reached only after important variables have been clearly identified and experimental conditions can be classified on the basis of the presence or absence of these variables

Part of the difficulty in obtaining a consensus on a term can be attributed to a lack of agreement on the appropriate referent Whatever the term personally preferred some investigators use it with reference to

the experimental conditions i e as an operational term referring to a certain set of experimental manipulations or to a *state of the organism,* i e as a variant of stimulus hunger or to *a phenomenological experience of the organism,* i e as a variant of stimulus-hungry Finally there are others (who appear at times to be the majority) who use their chosen term indiscriminately with all three referents

In addition to the disparate referents it can be seen from the list of terms used that they range from simple variations to those which reflect quite divergent conceptual levels and theoretical frames of reference These divergencies underlie many of the conflicting views concerning the significance validity or reliability of research results It would be as fallacious to ascribe these differences of opinion mainly to inconsistencies in the basic data (as is done so often in discussions of sensory deprivation research) as it would be to ascribe disagreements between orthodox analysts and behavior therapists to inconsistencies in basic data on behavior change *The inconsistencies most often are not in the data but in conditions under which data are collected in terms used and in interpretations of data* This is a state of affairs that seems to be readily recognized in other research fields but not yet generally recognized or incorporated into discussions of sensory deprivation research

Experimental Conditions

The constant reference in the literature to inconsistent and contradictory data on sensory deprivation gives a misleading picture of the field A true picture must incorporate the fact that methodologies employed to collect data have varied considerably The variance has been so great that the suprising feature is the amount of consistency in the data and not the apparent contradictions A preliminary conception of the variety of methods that have been employed can be gained from looking at Figures 2–1 to 2–9 They reveal a host of potentially important methodological differences It can be seen that subjects have been confined in rooms respirators and water tanks sitting lying down or floating in total darkness diffused light or subdued light in silence with reduced sound or with white noise for minutes or weeks allowed some or no movement with apparatus attached or relatively unencumbered and so on The effects of some of these specific procedural variables have received preliminary evaluation (see chapter 3) but differential effects of combinations of these variables are practically unknown

The range of experimental conditions has been so wide that attempts to devise even broad categories for classification purposes have not been particularly successful Most of the proposed classification schemes have been patterned after the one offered by Kubzansky (1961b) in which the term *sensory deprivation* refers to experimental environments designed to provide absolute reduction of intensity of input (e g silence and darkness)

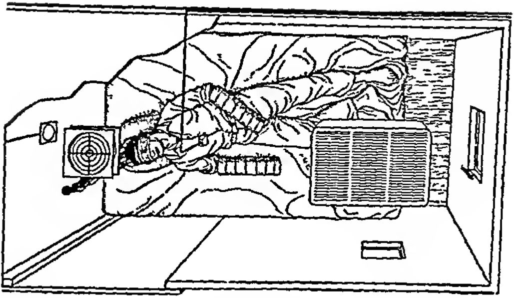

FIGURE 2–1 This condition was employed in the original McGill University studies, and it served as a prototype for subsequent perceptual deprivation research. Shown in this cut away diagram are an air conditioner, exhaust fan, and microphone above the subject, EEG leads attached to the subject's head, translucent eye coverings, and cardboard cylinders enclosing the lower portions of the arms. The room was dimly illuminated, but the subject's eye coverings prevented pattern vision. Amplifiers and other electrical equipment, causing a low hum in the earphones embedded in the U shaped, foam rubber headrest, were employed for auditory masking purposes. The subjects were scheduled for 2- to 3-day sessions with meals brought in and toilet facilities, in another room, made available upon request.

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and the term *perceptual deprivation* refers to experimental environments designed to provide solely homogeneous and unpatterned input (e.g., white noise and diffused light).

For want of a more efficient classification scheme, Kubzansky's broad, dichotomous classification is used throughout this book. However, the combinations of "absolute reduction" and "reduced patterning" that are possible when all sense modalities are considered (e.g., visual, auditory, tactile, olfactory, kinesthetic, gustatory, and proprioceptive) seriously limits (but does not nullify) the functional utility of this classification scheme. In practice, the classification is usually based solely on visual and auditory stimuli available to subjects. This restriction in criteria makes the classification process more feasible but it also makes it less meaningful

FIGURE 2–2. In this experimental condition, the subjects were isolated for up to 6 days although the usual duration was 4 days The chamber was dark and virtually soundproofed, and it contained a foam rubber bed, a chemical toilet, and refrigerated food. In most studies the subjects had minimal movement restrictions.

SOURCE: Reprinted by permission from T I Myers, D B Murphy, S Smith, and C. Windle, HumRRO res. memo., February, 1962

since the importance of amount and patterning of visual and auditory stimuli certainly is dependent on the amount and patterning of stimuli available to other sense modalities

Aside from the practical difficulties and limitations in this classification system it is disputable whether experimental conditions actually have differed significantly in *amount of reduction* of sensory input The water immersion technique (Figure 2–9) is often mentioned as one which provides a relatively drastic reduction in sensory input and yet even under these conditions subjects experience stimulation from various sources such as water ripples, blood pounding in ears and swallowing sounds Goldberger and Holt (1958) after some preliminary experience with the water immersion technique stated that These experiences make us doubt that the water immersion technique produces a marked reduction in the total amount of stimulation it would seem rather to supply steady inputs (e g from the breathing mask) or rhythmic stimulation (e g, from effortful breathing) thus providing different *kinds* of stimulation from those of the isolation room rather than quantitatively less input (p 111)

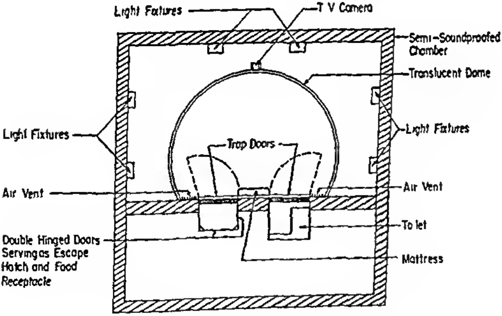

FIGURE 2–3 This uniquely constructed isolation chamber, equipped with a closed circuit TV system allowed long term studies (up to 2 weeks) to be carried out on either perceptual or sensory deprivation A double trap door arrangement made it possible to administer food and a variety of tests with no direct contact with the isolated subject In most studies the subjects were required to lie quietly

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FIGURE 2–4 This isolation room containing food and toilet facilities was created in an anechoic chamber The room was sound deadened (but not sound proof) and either illuminated or darkened according to design Subjects were isolated up to 2 days with few movement restrictions

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The question of how much difference really exists between various techniques in total amount of reduction in intensity of sensory input is an important one because the answer inevitably will be involved in explanations of results Those who believe that water immersion does provide the "most severe reduction in sensory input" are likely to relate unique results obtained with this technique to the "severe reduction" rather than to other factors which may be operative under such conditions For example,

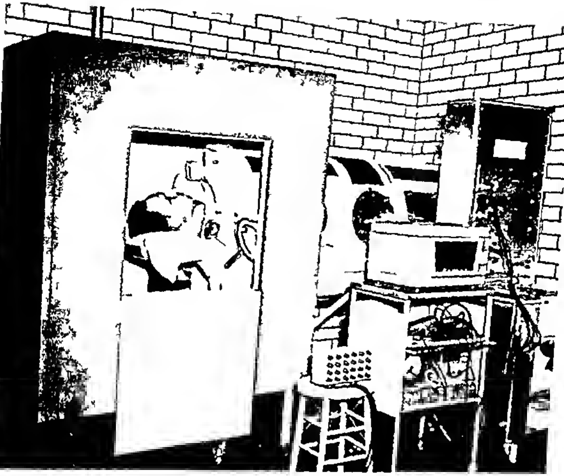

FIGURE 2–5 Th s tank type respirator was located in a large air conditioned room and the pictured recording instruments were located in an adjo n ng room during the actual experiments The subject s arms and legs were enclosed by rig d cylinders to inhib t movement and tactile contact The motor of the respirator produced a dull masking sound The enclosure around the head of the resp rator was closed during the experiment so that the subject could see only the front of the tank and the blank inter or of the enclosure The subject could drink a high caloric eggnog from a feeding tube placed close to his mouth and bedpans or urinals were given on demand The subjects were scheduled for up to 36 hour sess ons

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subject tolerance in water immersion studies generally has been limited to hours as contrasted with days in studies employing other techniques and this poor tolerance has been attributed to the purportedly greater reduc tion of sensory input If the water immersion technique provides differ ent *kinds* of stimulation rather than quantitatively less input

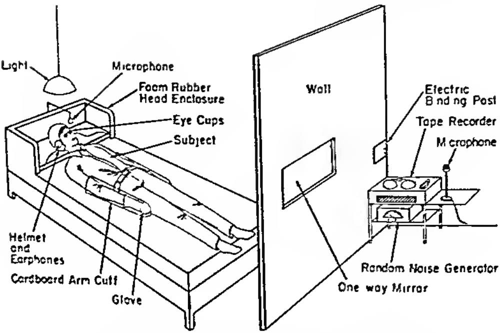

FIGURE 2–6 This experimental condition is a variation of the one employed in the original McGill University studies on perceptual deprivation The subjects were scheduled for 8 hour sessions during which time meals were brought in and toilet facilities in an adjoining room, were made available upon request

SOURCE Reprinted by permission from L. Goldberger & R. R. Holt, *J nerv ment Dis.*, 1958 127 99–112.

explanations of the comparatively low subject tolerance may be looked for in other areas such as discomfort of physiological effects of water immersion (wrinkling of skin changes in fluid and electrolyte balance) increased toileting and feeding problems pervasive fear of falling asleep and getting a mouthful of water or drowning and the use of highly selected subject populations

FIGURE 2–7 This experimental condition was specifically designed for short term studies (4 hours or less) in which the subjects were not fed or toileted during isolation and movement restrictions were severe. The room was air conditioned, white noise was used as a masking sound, and the subjects wore translucent eye coverings which diffused light from a bank of fluorescent bulbs. The subject's chair faced the fluorescent lights during the course of the experiment.

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FIGURE 2–8. In this condition the subjects lay supine under the translucent covering over the bed. The cover diffused light from a dimly-lit overhead lamp. Lightly bound straps were used on the arms and legs to inhibit movements, and white noise conveyed via earphones was used as a masking sound. The subjects were scheduled for 8-hour sessions and were fed and toileted at the 4-hour period.

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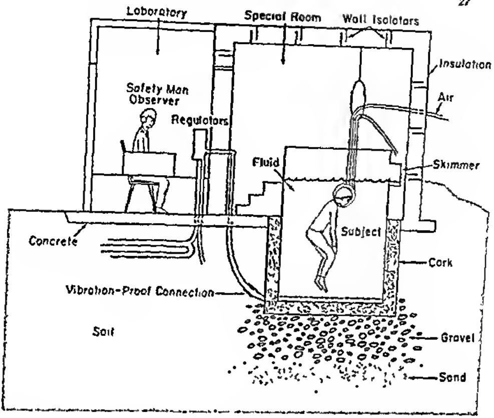

FIGURE 2–9. Hydrohypodynamic environment. The water-immersion condition is generally considered to be the most severe of all laboratory-created sensory-deprivation environments. Wearing nothing but a head mask, the subject is immersed in a pool of slowly flowing water (93 5° F) and instructed to inhibit all movements Because of its severity, this condition can only be used for short-term deprivation experiments.

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without interfering with sensory deprivation is inherently difficult to solve In fact, the difficulties in attempting to keep subjects in such environments without interruption for more than a few hours have resulted in a state of affairs that may be generalized as follows· the longer the period of sensory deprivation, the less severe the sensory deprivation conditions and the fewer the number of subjects studied Thus, studies of extended periods of sensory deprivation have the limitation of utilizing less severe experimental conditions and fewer subjects which narrow the generalizations possible. On the other hand, studies which utilize short periods of sensory deprivation, while using more drastic reduction of sensory input and more subjects, may be said to be analogous to studies of food deprivation in which subjects are without food for just a few hours

Of course, there are exceptions to these generalizations. The adequacy of research designs depends less on length of sensory deprivation

periods than on the skill, patience and ingenuity of individual investigators

Measurement Problems

Assessing changes associated with exposure to sensory deprivation is a challenging complex problem which has remained impervious to general solution thus far Even such a basic decision as to *when* measurements should be collected is still an issue

Measurements continuously collected during sensory deprivation have the obvious advantages of providing data on the course of changes occurring and data on the relation between changes However, these measurements have the distinct disadvantage of interfering with experimental conditions by providing stimulation of one sort or another Mere attachment of electrodes for bioelectric recordings introduces (aside from tactile stimulation and discomfort) an unknown amount of extraneous psychological factors into experiments For example some subjects may fear getting shocked despite assertions to the contrary others may use the attachments as a focus for reality thinking and still others may get comfort from the knowledge that their physiological condition is being monitored

Measurements of cognitive functions collected during sensory deprivation can result in even greater interference with experimental conditions Task or test stimuli usually provide complex prolonged input and there are indications that mere assignment of tasks can increase subjects vigilance and alertness and help to mobilize inner resources during sensory deprivation Measurements which depend on spontaneous verbalizations (e g continuous report instructions) allow subjects to provide themselves with self stimulation upon demand (vibration of vocal chords muscular effort involved in speech and feeling of social contact) For a stimulus-hungry subject this may be tantamount to receiving a reward for giving reports How this reward for report may affect the reliability of contents of reports remains to be assessed For example there are indications that subjects who talk the most under continuous-report instructions also report the greatest amount of deleterious effects (e g imagery or somatic complaints) (Zuckerman 1961b) A natural question is Did these subjects talk more because they experienced more deleterious effects or did they simply report more as an excuse to talk?

An additional limitation in collecting measurements of cognitive functioning during sensory deprivation is the necessity of assessing subjects level of arousal throughout the period of confinement Subjects differ in the amount of sleep they engage in during sensory deprivation (Mendelson et al 1961 Leiderman 1962 and Rossi Furhman & Solomon 1967) and this difference is liable to be reflected in other measurements (e g., measurements which depend upon spontaneous reporting) While it

might be argued that differences in amount of sleep during sensory deprivation reflect different reactions to sensory deprivation (and therefore its effects on other measures is inconsequential for their validity) sleep also reflects differences in amount of fatigue ability to sleep outside of one s own bed and basic anxiety Unless all other variables known to affect sleep are controlled it would be gratuitous to interpret sleeping during sensory deprivation solely as a defensive reaction to the experimental conditions

Even when all other variables affecting sleep are controlled there may still be a need to assess differences in amount of sleep and to take these differences into account when evaluating other measures As an illustration consider a study focused on the effects of prolonged viewing of horror movies in which half the subjects fell asleep at the outset Even if this sleep can be shown to be a defensive escape reaction subjects that slept and subjects that remained awake did not view horror movies for the same length of time and this must be taken into account in evaluating performances on other measures

Measurements collected immediately after sensory deprivation have the advantage of not interfering at all with experimental conditions therefore a greater variety of measures can be employed which have been selected solely on the basis of appropriateness rather than on how little they interfere with sensory deprivation However available data do not support the assumption of a linear development of psychophysiological changes over time in sensory deprivation Rather the data indicate that changes fluctuate with periodic dissolution and mobilization of inner resources Measurements confined to the immediate post sensory-deprivation period then have the disadvantage of possibly missing changes that occurred periodically during sensory deprivation but which were absent at the point of measurement or which dissipate rapidly upon termination of the sensory deprivation experience

The reliability and validity of post sensory-deprivation measurements which depend on subjects retrospective reports of experiences have not been clearly established These reports may or may not be affected by secondary elaboration unwillingness to admit unusual experiences after they have occurred and cues from the questions or questioners In short the purported unique value of sensory deprivation in producing experiences which can be studied while still on the griddle is lost by limiting measurements to the post sensory-deprivation period

Measurements collected after sensory deprivation pose a special problem which has not received adequate attention in the literature This problem is how to distinguish between sensory deprivation effects" and abrupt change effects The return to a variegated sensory environment from a sensorily deprived one may be sufficiently disrupting to produce effects in its own right For example some perceptual distortions that have

been reported by subjects upon release from sensory deprivation are highly saturated colors, apparent movement of objects with head and eye movements straight lines appearing wavy, and so on These same perceptual distortions were reported by other subjects not upon release from sensory deprivation but after removing inverted lenses that had been worn for 30 days (Snyder & Pronko 1952) In the latter study the distortions were described as 'abrupt change effects while in the former studies the distortions are described as 'sensory deprivation effects It is possible that both interpretations are correct in these instances but the possibility of both effects being confounded in post sensory deprivation measurements needs more recognition than it has received As stated by Ziskind (1964b) " the after symptoms of the deprivation experiments are not necessarily due to sensory curtailment (They) are probably to be explained on the basis that prolonged nervous reactions are not immediately relinquished as soon as the conditions giving rise to them are terminated (An example is the persisting unsteadiness in gait and associated sensations on first walking after a rocky voyage at sea) Livingston (1960) refers to such symptoms as ''commitment' of the nervous system not immediately relinquished (p 117)

In 1948 Miller demonstrated that in rats reared in complete darkness there are specific disturbance effects on first exposure to light that can be distinguished from effects due to the dark rearing itself He cautioned that these "abrupt-change effects need to be accounted for in studies of visual deprivation To a large extent, his caution seems to have gone unheeded in sensory deprivation studies employing human subjects Perhaps this is why some investigators find deterioration of performances immediately after sensory deprivation but not during it (Goldberger & Holt, 1958) and why there is more agreement in results obtained immediately after sensory deprivation than in those obtained during it ' especially those requiring relatively fine perceptual motor coordinations (Myers, 1964c, p 5) If people were found to have perceptual motor deficits immediately after being bombarded by sensory input would it be appropriate to attribute the deficits to the sensory bombardment to their prior 'sensorily deprived experience in the normal world or to the abrupt change?

In summary measurements collected during sensory deprivation can interfere with the very condition being studied and measurements collected after sensory deprivation can be unreliable miss periodically occurring effects and be confounded with 'abrupt change effects The verb can" is used here advisedly It is a matter for experiment to determine which measures are contaminated Obviously the nature of some measures collected during sensory deprivation interfere not at all with experimental conditions (e g biochemical analyses of urine that would be collected even without the planned analyses) and the nature and time lapse of other measures collected after sensory deprivation are less likely to be

contaminated by the factors mentioned (e g EEGs obtained a week after release from sensory deprivation)

Appropriateness of Measures

The problems mentioned above can lead to the use of measures that are selected more for their solution of these problems than for their adequacy and appropriateness in measuring hypothesized psychophysiological changes As some investigators have pointed out (Goldberger & Holt 1958 Suedfeld 1964b) the desire to interfere as little as possible with experimental conditions has led to the widespread use of simple short over learned tasks in assessing cognitive efficiency during sensory deprivation rather than more appropriate and sensitive tasks which require active reflection judgment and manipulation of ideas

At the other extreme test batteries administered after sensory deprivation at times have been so complex and time-consuming that performance decrements might be expected solely on the basis of subjects waning motivation impatience to get it over with and fatigue

The potential importance of mode of presentation of test materials also has been discussed in the literature (Zubek Sansom & Prysiazniuk 1960) Many investigators have presented test items to subjects aurally because it was more convenient or seemed to be less of an interference with sensory deprivation than arranging for visual presentations Yet the validity of the aural mode of presentation depends very heavily on subjects ability for short term retention If this one ability is affected deleteriously by sensory deprivation subjects performances may be poor on a range of test items assessing other cognitive abilities which may not have been directly affected

Other measures seem to have been selected primarily on the basis of availability rather than appropriateness For example multivaried globular pencil and paper tests such as the Minnesota Multiphasic Personality Inventory and Edwards Personal Preference Schedule have been used extensively in the search for personality correlates of specific reactions to sensory deprivation Their use reflected an optimistic view of the power of such tests In the early years of sensory deprivation research the use of these tests was sanctioned by the query "Who can tell what might be found but the results provided a negative answer to the query It now appears that if any paper and pencil test scores are going to be predictive of reactions to sensory deprivation the test will have to be specially constructed to assess personality characteristics that seem to have at least theoretical relevance to specific hypothesized stresses present during sensory deprivation An example of such a test is the Sensation-Seeking Scale (Zuckerman Kolin Price & Zoob 1964) which was constructed to measure the strength of a trait that logically appears to be an important personality characteristic in sensory deprivation research i e need for new sensations

The lack of appropriate measures is most evident in the study of imagery occurring during sensory deprivation The reported occurrence of hallucinations during sensory deprivation is one source of general interest in this field and a stimulus for much research being carried on Despite all the attention however this remains one of the most confused areas of sensory deprivation research and one beset with unresolved measurement problems Measures employed remain extremely crude and reported data remain limited in most cases to simple tabulations of incidence Problems of definition and criteria are recognized and discussed but many studies are still designed as if these problems did not exist Reports of studies seldom describe criteria in enough detail for the reader to know what relationship imagery in one study has to imagery in another study

retain the shortcoming of not making differentiations among *type* of imagery reported

The phrase reported visual (or auditory) sensation has been introduced as an operational definition of what is actually being measured in studies of imagery (Murphy Myers & Smith 1963 Zuckerman & Cohen 1964a) There are undoubted benefits in the use of operational definitions but their scientific aura can sometimes obscure irrelevant and inappropriate uses of such terms For example in this case the operational definition of the term explicitly limits its reference solely to *reports* Proper use of the phrase requires that differences between various imagery *experiences* be ignored and indeed that experience itself be ignored Because interest of much sensory deprivation research has been on imagery *experiences* (as reflected *in reports* but *not equated with reports*) the operationally defined term is inadequate in discussing these results or the interpretation of them For example practically no one would disagree with the statement that all *reported visual sensations occur during* awake or drowsy states during sensory deprivation when the term literally refers to *reports* That is it would be a rare investigator who believed that subjects were sound asleep when they *reported* a *visual sensation* There would be disagreements however concerning the level of arousal of subjects when they ex*perienced* the visual sensation being reported The use of an operationally defined term such as reported visual *sensation* is valuable when *it is* used consistently and appropriately It can only lead to additional confusion however when it is used inconsistently to refer to the report the experience or both

Baselines

Once the investigator has made his *decisions in* regard to the problems mentioned in selecting and collecting appropriate measurements *there still* remains the problem of evaluating results In early exploratory phases of the research it was sufficient simply to report whatever behaviors or psychophysiological changes that had been observed to occur However for the most part this phase of the research has passed and it appears that little is to be gained from simple accumulation of such data At a symposium entitled Sensory deprivation research Where do we go from here? held at the 1964 American Psychological Association meetings the single desired development advocated most strongly by participants was the collection and use of appropriate baseline data in evaluating results Like some other concepts that have high positive values however a clear definition of adequate baselines is not easily obtained This is a matter of no small import because as stated by Myers (1964c, p 4) Obviously the manner in which baselines are defined can profoundly affect experimental outcomes

It is not feasible to establish a general set of baselines for the occurrence of sensory deprivation phenomena (e g boredom imagery somatic complaints and slowing of alpha) in a normal environment since a normal environment is a highly abstract term referring to an infinity of specific environments Thus although it is generally agreed that the baseline for the occurrence of these phenomena outside sensory deprivation is greater than zero the actual baseline will vary with the purposes of the investigator and the conditions used in collecting baseline data *The use of baselines therefore, will allow a series of comparisons between different conditions but* not *a comparison between sensory deprivation and a standard condition called normal* This may seem an obvious point but it is not unusual to read discussions in the literature that seem to assume that the mere occurrence of a phenomenon outside sensory deprivation conditions precludes the possibility that it is also directly related to sensory deprivation conditions It is a barrier to scientific knowledge simply to label a phenomenon normal (without specification of normal conditions) with the implication that the label explains its occurrence under sensory deprivation conditions Rather understanding of a particular phenomenon is enhanced by identifying the range of conditions which produce it and determining what these conditions have in common

If the phenomena most consistently observed under sensory deprivation conditions were observed *only* under these conditions and no other they would be of slight scientific interest It is precisely the fact that they are observed elsewhere that provides the scientific value of sensory deprivation research The function of baselines therefore is not solely to demonstrate that sensory deprivation conditions produce unique phenomena or more of a given phenomenon than other conditions but in the provision of data for comparing the form and frequency with which the phenomenon appears under experimental and baseline conditions When used for the latter purpose baseline data can be extremely valuable in interpreting research results

Control Data

The collection of appropriate baseline data is not always a straightforward task in this area of research The value of such data is directly proportional to their comparability with data collected under sensory deprivation conditions—comparability in subjects used experimental rigor used in the collection and degree of specification of conditions under which they were collected These necessary characteristics for appropriate baseline data seem so self-evident that it would be trivial to discuss them further except for the extent to which they apparently are ignored in the literature

For example the baseline data most often used are those collected under what are called "control conditions with the use of control

groups The obvious high positive value of the term control can blind some to inadequate inappropriate or irrelevant aspects of some of these data It is not unusual to read reports in which evaluation of data collected under rigorous experimental conditions is based directly on results of comparisons with data collected under a poorly defined vague set of conditions called control This is apt to be particularly true when the control conditions consist solely of subjects leaving the laboratory area for a time period equal to the sensory deprivation time period and no effort is made to ascertain what experiences subjects had during the control period e g was it a particularly hectic period for subjects (exam week)? and did they gather information pertaining to tests they took before the control period began and will take again at the end of the control period? The use of this type of control condition seems to be based on the assumption that subjects experiences will be randomized—an assumption that is disputable with the small time periods and few subject *N*s customarily used in this area of research

Adequate control group data most often are collected under a specified set of laboratory conditions Here the problem focuses on the comparability of subjects used in experimental and control conditions Obviously the surest way of insuring comparability is to use each subject as his own control when possible This is particularly true in sensory deprivation research where large individual-difference effects have been reported for almost every measure or set of experimental conditions employed However the use of each subject as his own control introduces its own problems including the need to evaluate the effects of different sequences and repeated exposures These problems usually make it more convenient to use different groups of subjects for each condition rather than each subject as his own control The use of control groups in an area of research with large individual difference effects is appropriate when subject *N*s are large or when control and experimental groups have been matched on crucial variables Because crucial subject variables are as yet largely unknown in sensory deprivation research groups have been matched primarily on the basis of demographic variables (age sex and education) none of which has been consistently demonstrated to be an important variable Thus matched controls in sensory deprivation research are more often based on hope than fact that the matched variables are relevant

The use of randomly selected groups for experimental and control conditions is the accepted practice when important subject variables are either unknown or too numerous for matching However as mentioned above individual difference variances are known to be large in sensory deprivation research so large in fact that in some studies investigators have concluded that their data indicate that the differences in response are much less a function of the conditions of the experiment than the personality of the subject (Zuckerman Persky Hopkins & Murtaugh

1965, p 6) and the presence or absence of imagery is related to the subject and not to the conditions of deprivation (Leiderman, 1962, p 74) When individual differences are this potent, adequate randomly selected groups require large *N*s much larger *N*s than have been used in most sensory deprivation research because of time and manpower costs

There have been many advocates for the increased use of control data in sensory deprivation research, and the advocacy is a sound one However, much more thought is needed to spell out the requirements for control data since poor control data are not necessarily better than no control data, and, in fact, poor control data are often worse because they may deceptively cover up other limitations of the data

Formulation of Research Questions

Many of the research questions formulated for this area of research seem to be based on the assumption that the causative agent in the production of observed psychophysiological changes is the *absence* of exteroceptive stimuli, i e, that nothing in itself, can cause something Although this loose conceptualization may be adequate for some purposes it seems totally inadequate for seeking and understanding relationships among experimental data *The reduction of exteroceptive stimuli is merely the condition under which other variables interact* Most of the research to date has been focused on recording net results of interactions and not on the components and nature of interactions The net results are interesting and valuable preliminary data, but as long as they remain the focus of attention and are described as *direct effects* of sensory deprivation with the implication that nothing (no sensory input) *caused* the results, they will continue to be immune to understanding prediction and control

As an analogous situation, consider the state of affairs that would have existed in primitive times if numerous, uncoordinated studies were carried out on the effects of partial (sometimes severe, but never total) food deprivation With our present knowledge of biochemical and metabolic processes we could predict that these studies would have produced results that were 'confusing inconsistent and contradictory Some would have shown that food deprivation caused loss of weight, increase in thirst, hallucinations and irritability and others would have shown contradictory results Today we would know that these studies could not have produced consistent results without controlling or accounting for different metabolic rates of subjects the caloric value of foods still available to subjects the hunger state of subjects before the start of the studies the duration of the partial food deprivation and most importantly the combination of these variables As long as these hypothetical investigators continued to conceive of their results as direct effects of food deprivation there would continue to be meaningless discussions as to whether food deprivation did or did not cause particular effects and whether the results were artifacts Understand

ing would come when they began to focus their attention on what processes were actively producing observed phenomena

For similar reasons understanding prediction and control of sen sory deprivation phenomena will progress with a shift from broad ques tions requiring dichotomous answers to questions allowing more graded answers Such broad questions as Are sensory deprivation images real hallucinations or are they dreams? Do extraverts have a higher tolerance for sensory deprivation than introverts? and Is learning facilitated or inhibited by sensory deprivation? are stated in a form that inevitably will produce conflicting answers from study to study when measurements cri teria and experimental conditions vary as much as they do in this research area These same questions usually can be stated in a form (e g What are the characteristics of imagery that occur at various levels of arousal during sensory deprivation? How does the extraversion intraversion dimension interact with experimental variables to produce differences in tolerance? and What are the variables influencing facilitation or inhibition of learn ing under sensory deprivation conditions?) that will produce more mean ingful and consistent results

This is more than just a matter of semantic preference since the form of the question will determine the nature and efficacy of the research de sign For example a problem of much interest has been the extent of sug gestion influences in the production of observed sensory deprivation phenomena When this problem is formed into a broad research question requiring a dichotomized answer the research may produce results which provide the dichotomized answer (e g yes sensory deprivation phenomena can be produced by suggestion) but the results may be tangential to the original problem That is very few investigators doubt that suggestion may have some influence even when precautions are taken so that the problem to be solved is the extent of the influence under usual sensory deprivation conditions One of the most curious paradigms used to provide data relevant to the solution of this problem is one that does not em ploy a sensory deprivation environment! The reasoning behind such a paradigm appears to be that if it can be demonstrated that suggestion alone produces a particular phenomenon then suggestion must be con sidered a potent influence in the production of the phenomenon under sensory deprivation conditions This reasoning implicitly or explicitly stated is specious without at least a demonstration that the phenomenon is indeed similar in all respects under both sets of conditions Even if the similarity were established the relevance of the extreme suggestive procedures employed in these studies to the more subtle suggestion influences present in the great majority of sensory deprivation researches would be questionable

To illustrate this point consider the fact that most subjects in sen sory deprivation researches have been paid for their participation Un

doubtedly their receiving pay must have some influence on their reactions to the experimental conditions The problem though is the nature and extent of the influence enough to throw doubt on the validity of results obtained in studies which did not explicitly control or partial out the pay influence or is the influence inconsequential in the presence of more powerful influences present in experimental conditions? A study in which subjects are not placed in sensory deprivation and simply bribed to respond in a certain way (e g I ll give you 10 dollars if you say you see a dragon right now) will undoubtedly elicit responses similar to those reported in sensory deprivation research However the results of this study will be irrelevant to the problem of evaluating the influence of paying subjects on responses to sensory deprivation

Inherent in the above discussion is the assumption that two grossly defined sets of conditions (e g sensory deprivation and suggestion) conceivably can bring about the same phenomenon (e g reports of imagery) through two different mechanisms The mere demonstration that either set of conditions produces the phenomenon provides no understanding of the mechanisms by which the other set of conditions produces it *This is especially true when the mechanisms of neither set of conditions are known and when there is no convincing demonstration that the phenomena are actually identical* The failure to provide the latter demonstration most often lies not with investigators but with classifications and measurements used in sensory deprivation research which tend to be vague gross, or imprecise For example it was mentioned that imagery measurements are often limited to incidence with no differentiation among *types* of imagery Other writers have pointed out the need for evaluation of other dimensions of imagery in sensory deprivation research (e g vividness structure and persistence) (Goldberger & Holt 1958) and that these dimensions can vary independently from one another (Leiderman 1962 Cohen Rosenbaum Dobie & Gottlieb 1959) It is difficult to see how realistic comparisons can be made of results achieved in different studies until measurements become more differentiated and precise

Research Strategies

The difficulty of directly comparing results obtained by different investigators working in different laboratories is one of the most serious problems in sensory deprivation research *Even if measuring instruments and experimental conditions were to become more uniform results would still be difficult to compare if studies remained as unfocused and isolated as they tend to be at present* The era of one-shot studies began before sensory deprivation research appeared on the scene so their presence in the latter field is by no means unique Their commonness however does not redeem their shortcomings

The rationale for this approach to scientific knowledge seems to be that if masses of data are collected over a long enough period of time lawful patterns will eventually emerge This belief is most plausible when the field of research is highly developed in terms of objective quantified measurements and detailed specification of experimental conditions which allow direct replication of results In a field as experimentally underdeveloped as sensory deprivation research the ultimate scientific value of large numbers of isolated uncoordinated I wonder what will happen types of studies is open to question

The gross phenomena associated with sensory deprivation conditions are well enough known to support the development of programs of theoretically derived hypothesis testing types of studies Series of studies zeroing in on the solutions to circumscribed problems hold the highest promise of establishing a body of facts concerning effects associated with sensory deprivation conditions As stated by Kubzansky (1964 p 5) It is in the system atic pursuit of questions within the same laboratory over long periods of time that there is meaningful promise of resolving the ambiguities and uncertainties of our present knowledge By such an approach we come close to meaningful and precise replication of conditions precise specification of variables and awareness of necessary controls

In addition to programmatic series of studies focused on circumscribed problems there is also a need for such series focused on the reactions of single individuals The systematic intensive study of even one appropriately selected subject could provide valuable clues concerning some of the variables operative under sensory deprivation conditions and how these variables interact to produce observed effects The accumulation of such data from a number of individual subjects would have some distinct advantages over data consisting of averages obtained from groups of subjects (see Brunswik 1940) As pointed out by Shmavonian (1964 p 18) In our approach we average out all our *Ss* performances and come up with averaged curves which (do not) represent the individual *Ss* These averages have not proved to be predictive of subject s performances and they lend themselves to misleading statements such as extraverts tolerate sensory deprivation better than introverts rather than more accurate statements such as More extraverts tolerate sensory deprivation better than introverts but some introverts tolerate sensory deprivation better than some extraverts Studies of individuals are more likely to keep the relative aspects of such findings in focus and less likely to lead to misleading generalizations

One of the most essential characteristics of sound research strategies is the employment of harmony and balance within research designs Unbalanced designs include such practices as collecting precise detailed measurements under poorly controlled experimental conditions or collecting subjective measurements under tightly controlled experimental

conditions, or carrying out sensitive, complex statistical analyses on obscure and unreliable measurements, and so on. The results of such lopsided research designs can be a major source of confusion, misunderstanding and controversy when the results are interpreted and discussed as if the whole design were as rigorous as its most precisely formulated parts.

Publication

Research tends to be designed and results interpreted on the basis of previously published material. To the extent that this material is misleading or distorted, research designs and interpretations of results will be inappropriate and erroneous. There is no reason to believe that these distortions are greater or more extensive in the field of sensory deprivation research than in any other field, but this does not lessen their importance as a methodological consideration in conducting sensory deprivation research. These distortions rarely grow out of deliberate choices by individual investigators, but rather they appear to be primarily a function of publication requirements. This conclusion is based on the fact that what an investigator will say about his research in personal communication is often very different from what he evidently felt compelled to say to meet publication requirements.

One example of these requirements is the widespread use of statistical tests of significance in evaluating and interpreting data. Their inclusion in reports often can be a *sine qua non* for publication. The stress on these tests has reached the point where it seems that a demonstration of logical significance of results is considered a *fait accompli* with a report of statistical significance. This has resulted in publications wherein statistically significant, low rank-order correlations between pairs of vague measures of questionable reliability found in a poorly defined population under loosely controlled experimental conditions are reported and discussed as establishing definite relations between given variables. An indication of the true worth of most of these statistical tests of significance, however, can be gleaned by noting the frequency with which investigators easily "explain away" statistically significant findings of other authors which are not consistent with their own theses. Few investigators seem to be personally convinced by the results of statistical tests of significance (primarily because of an awareness of the limitations inherent in the data used in the statistical analyses), but evidently they feel they must resort to the use of statistical reasoning themselves in order to achieve publication. This results in the ironic situation where publication can garble communication between investigators rather than facilitate it. The foregoing is not a denegation of the important and unique functions of statistical analyses when used as a means of arriving at judgments concerning data and not as an arbiter of what is or is not scientifically significant (see Hogben, 1957).

Methodology in sensory deprivation research can gain considerably by the institution of as much experimental rigor as possible while avoiding pseudoprecision and premature quantification. Ultimately, methodology reflects the caliber of investigators, and methodology in sensory deprivation research will be sound to the degree that the research is conducted by competent, curious, inventive scientists who will not abdicate their responsibility to exercise their reasoning and judgmental powers.

SUMMARY

Some general methodological issues involved in sensory deprivation research are presented in this chapter. Some of these issues are inherent in most new fields of inquiry. For example, a basic methodological problem in a new field is how to conduct controlled research without knowledge of which variables are effective and need controlling. The common device of resorting to exploratory research (i.e., incompletely controlled research) in such situations inevitably produces results that are inconsistent and apparently contradictory. A search for regularities among these results is hampered by the lack of a standard terminology which distorts communication among investigators.

The experimental conditions employed in this field have varied considerably, and inconsistencies in data may be partially a reflection of this variance. Absolute reduction of stimuli is not feasible with functioning human subjects, so that experimental environments have produced only partial reduction and depatterning of stimuli. Differences in residual stimuli in such environments can be expected to be greatly magnified because the fewer stimuli available, the greater the probability that each stimulus will be effective. Clearly, if subjects could be completely deprived of all stimuli except one, the nature of that one remaining stimulus would be crucial in predicting reactions. Attempts to develop classification schemes for categorizing experimental environments are hampered by paucity of knowledge concerning fundamental parameters of such environments.

Human subjects must be fed, toileted, and exercised, and these needs pose an inherent methodological paradox. Satisfying these needs entails an interference with sensory deprivation, and failure to satisfy them entails either a confounding of experimental conditions (e.g., sensory deprivation *plus* food deprivation) or the use of a very limited experimental time period.

Collecting measurements of effects associated with the experimental conditions is an equally vexing problem. Measurements collected during sensory deprivation can interfere with the very condition being studied, and measurements collected after sensory deprivation can be unreliable

miss periodically occurring effects and be confounded with abrupt change effects Subjects differ in their amount of sleep during sensory deprivation and this difference results in different amounts of (conscious) exposure to experimental conditions For some measures it is essential that these differences be taken into account in evaluation of results

These problems can lead to the use of measures that are selected more for their solution of these problems than for their adequacy and appropriateness Measuring instruments that are available and which minimally interfere with experimental conditions and measures which are easily collected are enticing but sometimes inadequate This is apt to be particularly true in attempts to measure intrinsically subjective phenomena such as discomfort and imagery

Meaningful interpretation of obtained results depends on the availability of adequate comparative data Increased collection and use of baseline data will aid interpretation if the baseline data are indeed comparative However the establishment of appropriate baselines for the type of phenomena involved in sensory deprivation research (e g boredom imagery and brain activity) is not a clear and easy task Considering the complexity of the human organism and the infinite variety of environments it is possible but unlikely that baselines for the occurrence of these phenomena under a standard environment called normal will be established Baselines therefore will vary with the purposes of the investigator the conditions and the subjects used in collecting baseline data

One form of baseline data is obtained with control subjects under control conditions To insure maximum utility of these data control and experimental conditions should be designed with equal vigor and control and experimental subjects should be comparable Often a control condition will not be specified further than to indicate that it was not the experimental condition and control subjects will be simply nonexperimental subjects In an area of research with such large individual difference effects the application of the term control in such cases seems euphemistic

The manner in which research questions are formulated influences the design of research and interpretation of results At this stage of the research it appears that formulation of research questions on the assumption that absent or reduced sensory input directly causes results will lead to continued accumulation of data that will remain immune to understanding prediction and control The absence or reduction of sensory input is merely the condition under which other variables interact, and knowledge concerning these variables and their interactions will require increased sophistication in the formulation of research questions For example questions allowing graded answers would appear to hold more promise of producing meaningful and consistent results than those requiring solely a broad dichotomous answer

The difficulty in comparing and integrating results obtained by different investigators working in different laboratories will continue to exist as long as studies remain relatively unfocused and discontinuous. Research strategies which involve conducting series of studies on the solution to circumscribed problems or on the reactions of single individuals would seem to hold the highest hope of producing stable replicable data. In addition the employment of harmony within research designs (in regard to degree of rigor of various aspects) will do much to avoid confusion misunderstanding and controversy regarding interpretation of results.

Pressures for publication coupled with publication requirements can lead to distortions in communicating results. These pressures can lead to premature quantification and the abdication of scientific reasoning to results of dubiously appropriate applications of statistical theory to obscure measurements of vaguely defined phenomena.

The presence of these methodological problems makes it understandable why specific results tend to be unstable from study to study. Focusing on the differences in these results and interpreting them to mean that most of the results are methodological artifacts reflects a misunderstanding of the field, its problems, the tentative status of much of the data, and the process involved in the development of scientific knowledge. Focusing on the similarities in these results (as is done throughout this book) can provide clues to important variables and their interactions which will facilitate the development of the type of controlled research which produces consistent, replicable results.

II

Experimental Findings

3

Variables Affecting Deprivation Results

Marvin Zuckerman

The sensory deprivation (SD) experiment is a nightmare to the experimentalist who craves clean cut, well controlled experimental situations. The SD experimentalist aims at producing an environment in which there is a minimal or constant sensory input. Rossi has described these methods in chapter 2. Experimenters have put subjects into soundproof cubicles, iron lung respirators and womblike tanks of body temperature water. Vision has been restricted by darkness, goggles, ganzfelds, halved Ping Pong balls and eye patches. Audition has been restricted by sound proof and sound attenuated rooms, ear plugs, earphones, masking noises and white noise. Tactual sensitivity has been restricted by gloves and cuffs. Maintaining a subject for any length of time poses many logistic problems. The subject must be fed, watered, and facilities for elimination must be provided.

In order to effect sensory reduction, certain other variables are necessarily introduced. Figure 3–1 shows some of these concomitantly varied conditions. The subject in the typical experiment is not only perceptually restricted, but his movement is restricted, and he is socially isolated for different durations of time.

The situation is an extremely ambiguous one for the subject. In most experiments a subject is assigned a task and stimulation of various kinds is introduced. In SD the subject is told to do nothing and there is no stimulation. Under such conditions we might expect personality and set variables to play a major role in determining the subject's responses to this live inkblot. Most of the early experiments on SD (Solomon et al 1961) simply examined the responses to the total situation with little or no attempt to vary the elements of the SD situation. This chapter will deal primarily with studies which have varied some aspect of the experimental situation or the subject population. Some comparisons will be made between different experiments where there was a common response variable.

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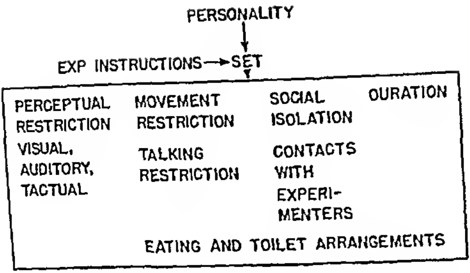

FIGURE 3–1 Factors which might affect the results in sensory and perceptual deprivation experiments

EXPERIMENTAL VARIABLES

Types of Experimental Confinement

Three major types of experimental confinement have been used bed-confinement in a sound attenuated or soundproof room, confinement in a tank type respirator, and suspension in a water tank Figure 3–2 shows the endurance in experiments in the three situations in terms of the percentages of subjects remaining at various points up to 10 hours of isolation Smith and Lewty s (1959) study was used because, unlike most other bed-confinement studies, the duration of the experiment was left up to the subjects as it was in the water tank experiments The limit of the respirator studies was set at 36 hours, but the subjects were told that they could terminate whenever they wished and most did so before the 36 hours were up

From the figure it can be seen that endurance is poorest for the water tank studies and best in the bed-confinement experiments The respirator type confinement is intermediate in endurance results In addition to the water tank studies in Figure 3–2 a study by Francis (1964) done in Australia, found that only 38 percent of a group of 24 subjects were able to stay in underwater confinement for a brief period of 3 hours There was no difference in the endurance of five amateur SCUBA divers and the other subjects or between males and females

Shurley (1966) provides data on two methods of water tank confinement one in which the subject is completely submerged wearing a breathing mask and floating up-right (dead man s float) and the other in which the subject is suspended horizontally on his back near the surface

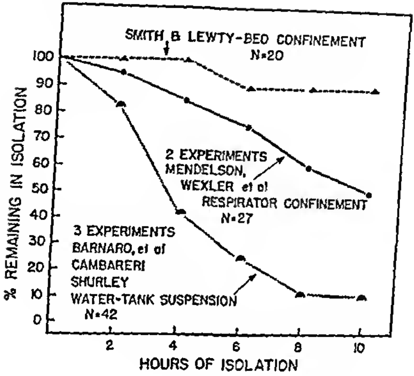

FIGURE 3–2 Comparisons of endurance in three types of confinement

of the water and with his head supported so that he breathes room air In the face down condition endurance data is provided on 19 runs by ten subjects In the face up condition data is given for 8 runs by seven subjects Some runs were terminated by the observer and some by the subject The experimenter s reasons for terminating the runs are not given In the face down condition only two subjects (20 percent) remained 6 hours and none remained 8 hours In the face up condition five subjects (71 percent) were able to remain 6 hours and four subjects (57 percent) remained 8 to 12 hours The apparently lower endurance in the face down condition might be due to any of several reasons including fear of losing one s air supply sensitization to the mask or the sounds of one s breathing or greater sensory deprivation and separation from the environment Unfortunately Shurley does not provide additional data beyond the endurance times

The poor endurance in the water tank studies is not related to a greater amount of verbalized anxiety in these subjects Anxiety was reported by only 45 percent of Cambareri s (1959) subjects but was given as part of the reason for terminating by all of Smith and Lewty s (1959) subjects and by 53 percent of the subjects in the Wexler Mendelson Leiderman and Solomon (1958) and Mendelson et al (1960) respirator experiments It may be that the subjects in the respirator and water tank

studies terminated before anxiety was recognized as such One other reac tion stands out in the water tank studies the high incidence of personal fantasies In his pioneering study using himself and another person as a subject in the water tank Lilly (1956) reported reveries and fantasies of a highly personal and emotionally charged nature too personal to relate publicly (p 7) Cambareri (1959) reported that 80 percent of his water tank subjects had recurring fantasies 40 percent were of a sexual nature and 20 percent were aggressive The percentage of subjects report ing fantasies in other types of confinement conditions is more typically 30 percent About 36 percent of the subjects in the water tank studies re ported structured meaningful Type B (see chapter 4) visual sensations and 25 percent of the respirator-confined subjects reported these types of hallucinations Only one of 20 subjects in Smith and Lewty s experi ment reported a Type B visual sensation although many other bed confinement experiments have yielded higher incidences

It may be hypothesized that the water tank confinement is more conducive to primary process thinking and this type of thinking may vary as a function of the completeness of the separation from the normal en vironment The complete helplessness and dependency in the water tank and to a lesser extent the respirator-confined subject may also stimulate regressive tendencies

Sensory vs Perceptual Deprivation

Two major kinds of sensory restriction have been used (1) Sensory Deprivation (SD) or conditions of darkness and silence (2) Perceptual Deprivation (PD) conditions of homogeneous visual stimulation using translucent goggles or a ganzfeld and constant masking or white noise stimulation

Heron (1961) suggested that PD conditions produced more hallu cinatory activity than SD conditions In their review of subsequent studies Zuckerman and Cohen (1964b) concluded that there was no further evi dence to support this hypothesis

Freedman and Greenblatt (1960) tested ten subjects after SD condi tions and ten subjects after PD conditions There were no differences between the groups in postexperimental reports of visual imagery audi tory imagery body illusions difficulty in concentrating inability to talk anxiety loss of time sense fears or fantasies All of the subjects in both groups were able to endure the 8 hour experiment On a battery of per ceptual tests given after isolation the SD group differed significantly from the PD group on only one measure the PD group reported more per ceptual distortions of simple figures after isolation than the SD group

Zubek and his co-workers (Zubek Sansom & Prysiazniuk 1960 Zubek Pushkar Sansom & Gowing 1961 Zubek et al 1962) studied one group of subjects in SD conditions for one week and another group in PD

conditions for one week Almost the same percentages of subjects (73 percent of SD s 69 percent of PD s) were able to stay in isolation for the full week Visual sensations of the simple A variety were more frequent in the SD condition while the more complex type B RVS s were rare or absent in both conditions Zubek et al (1962) found significant impairment on 8 of 12 cognitive tasks in the PD condition in contrast to only four tests which showed impairment in the SD condition Furthermore different types of tests were affected by the two conditions Recall and recognition tests were impaired by SD only while numerical facility verbal fluency and abstract reasoning were affected by PD only

In the PD condition significant effects were found on five of eight perceptual tests while in the SD condition only one of seven tests showed significant impairment relative to the control group Performance on a visual vigilance task was significantly impaired in both conditions while color perception and rate of reversal of reversible figures were only impaired by PD conditions

While neither SD or PD seem to be more stressful as measured by endurance or verbal reports PD seems to produce a more extensive cognitive and perceptual impairment than SD

Ganzfeld vs Goggles

Two forms of PD have been used by experimenters a ganzfeld usually in the form of a semicylindrical dome and translucent goggles which admit diffuse light but prevent patterned form perception In the dome ganzfeld the subject can see parts of his body the bed and some objects such as a microphone Pollard Uhr and Jackson (1963a) compared a group of 24 subjects restricted by the ganzfeld dome and 12 subjects restricted by translucent goggles The confinement period for both groups was 8 hours There were no significant differences in endurance time or self report effects and there were few differences between the groups on behavioral tests The goggles group showed more change in depth perception and less change in estimating speed of movement and word making

Total vs Partial SD or PD

Since more than one sense modality is restricted in the usual SD experiment it is of some interest to compare the relative effects of combined visual and auditory restriction with the effects of restriction of either visual or auditory perception

Leiderman (1962) ran a well-designed study in which the same six subjects were exposed to each of four conditions on four different occasions vision present sound absent vision absent sound absent (PD) vision present sound present and vision absent sound present In the vision absent condition vision was restricted by translucent goggles in

the vision present condition it was restricted only by the walls of the isolation chamber In the sound absent condition a white noise of fixed intensity was played into earphones in the sound present condition beating drums of variable intensity were interspersed with the white noise Each session lasted one hour The order of conditions was systematically varied across subjects to counterbalance the order effect

Although the small number of subjects in this experiment makes statistical test of the effects questionable the results are worth examining Three of the subjects reported imagery in all four situations The presence of variations in visual or auditory stimulation made surprisingly little difference in the incidence of imagery in these modalities Most reports of mental phenomena such as daydreams fantasies and delusions also occurred in all conditions Fantasies were about four times as frequently reported in the condition of vision absent–sound present as in the other conditions Galvanic skin potential and heart rate also showed little effect of conditions although heart rate was highest in the vision present–sound absent condition for four of the six subjects Body movements were also highest in this condition for four of the six subjects General complaints of discomfort occurred most frequently in the total PD situation Reports of fear anxiety and somatic complaints were most frequent in the two sound absent conditions Overall the results do not indicate impressive differences in the stress-inducing value of total PD as opposed to partial PD The stimulation provided was minimal meaningless and monotonous which might account for the lack of differences between conditions

Zuckerman Levine and Biase (1964) and Biase and Zuckerman (1967) compared the effects of total and partial SD in 36 male and 36 female subjects during 3 hours of confinement Three conditions were used (1) vision absent–sound absent (total SD) (2) vision absent–sound present and (3) vision present–sound absent The vision absent condition was darkness while in the vision present condition the lights in the soundproof room remained on The sound absent condition was maintained by the soundproof room while the sound stimulation condition consisted of continuously playing music of the Muzak variety One third of the males and one third of the females were confined in each of the conditions Significant differences were found on GSR measures of arousal Conductance rose more with duration in the total SD than in the partial SD conditions and more nonspecific GSR fluctuations occurred in the total than in the partial SD conditions In the females more nonspecific GSR s appeared in the light-deprivation condition but this result was not found in the males or in the combined group Differences between conditions were not found on verbal stress measures including the Multiple Affect Adjective Check List (Zuckerman & Lubin 1965) a somatic check list and a post experimental interview although all conditions produced moderate in

dications of stress Reported visual sensations were significantly more frequent in the total SD and the visual deprivation condition than in the vision present condition Auditory sensations other than the music were reported in all conditions and the differences between conditions were not significant Somesthetic sensations were reported more frequently in the total SD than in either of the partial SD conditions

The results of these experiments do not offer much evidence of a sensory deprivation effect as opposed to the general effect of a monotonous environment and social isolation There is some evidence in the latter study that the total SD situation may be more physiologically but not more psychologically arousing than partial SD However in studies ex tending beyond 6 hours more anxiety was found in SD than in social isolation (Zuckerman et al 1966) Leiderman did not find stress differ ences but he only exposed his subjects to one hour of confinement The GSR differences between total and partial SD conditions in the Zucker man experiments were not apparent in the first hour of SD

Total SD also seems to produce more somesthetic sensations perhaps because this is the least restricted modality and therefore dominates the field of attention In a second experiment Leiderman (1962) also found that somesthetic sensations were reported more often when vision was restricted than when vision was present The findings in the Zuckerman experiments regarding visual sensations simply indicate that visual imag ery is more difficult in a lighted room than in a dark room Leiderman did not find this difference possibly because he used a homogeneous visual field to restrict vision rather than darkness

Restriction of Movement

Subjects in most SD experiments are confined to a recumbent posi tion except for periods of attending to bodily needs This restriction of movement could be a significant factor in producing the stress and other reactions observed in SD experiments

Zuckerman Albright Marks and Miller (1962) compared an SD group confined in a tank type respirator a group confined in the same respirator without perceptual or social isolation and an ambulatory con trol group free between testings The confinement non SD group fell between the SD group and the control group on most verbalized stress indicators The SD group significantly exceeded the confinement and the control group on anxiety measured by the MAACL checklist and somatic complaints measured by the somatic symptom checklist The confinement group exceeded the control group on the latter measure The results seemed to indicate that confinement did produce some stress particularly bodily discomforts and thinking difficulties but that SD added signifi cantly to these stresses On measures of loss of verbal productivity and deviancy from popular responses on word associations the SD group dif

fered significantly from the ambulatory controls, but the differences with the confinement group only approached significance

Zubek and MacNeill (1966, 1967) and Zubek and Wilgosh (1963) have studied and compared the effects of recumbency and more severe immobilization with ambulatory controls and SD groups confined for a period of one week The recumbent and immobilized subjects in these experiments were provided with perceptual and social stimulation The recumbent groups were confined to a bed, but their movements not otherwise restricted, the immobilized group was confined to a foam rubber-lined 'coffin" like box with straps and a head retainer which severely restricted their movements All 22 subjects immobilized, but not perceptually restricted, were able to endure the week of confinement Similarly, all of the recumbent controls in the Zubek et al (1962) experiment endured a week of confinement In contrast, only about two thirds of the subjects in SD or PD (Zubek et al, 1961, 1962) were able to endure a week's confinement In terms of the gross endurance data it would seem that confinement or immobilization play no role in SD stress However, the data from the Myer's (1962) Post Isolation Questionnaire, used in the Zubek and MacNeill (1967) study, reveals that some of the subjective SD or PD effects are due solely to perceptual restriction, others are due to a combination of perceptual restriction and confinement, while some are produced by confinement alone The one week PD group was significantly higher than both confined recumbent and ambulatory control groups on the following scales reported visual sensations, loss of contact with reality, changes in body image, speech difficulties, reminiscence and vivid memories sexual preoccupation, temporal disorientation, and positive attitude toward experimenters The first four scales represent a statistically derived factor which Myers identified as Unreality Stress and the first three scales were part of the rationally derived factor which Zuckerman et al (1966) called Primary Process Both the perceptually restricted and confined recumbent subjects reported a higher incidence of worry and fright, inefficiencies of thought, subjective restlessness complex and vivid dreams and hunger than the ambulatory controls The PD group was significantly higher than the recumbent group on only one of these scales inefficiencies of thought The first three scales constitute the factor which Myers calls Tedium Stress Other scales seemed to be affected by a combination of PD and recumbent confinement tedium, religious preoccupation, changes in self appraisal, novelty, and surprise

Zubek's results tend to implicate confinement as a primary source of the subjective stress in SD or PD It would appear that many of the so called isolation effects mentioned in the literature probably resulted to some extent from the recumbent position rather than from a reduction in the over all level of sensory stimulation (Zubek & MacNeill, 1966) This conclusion has also been reached by Zuckerman et al (1966) and Persky,

Zuckerman Basu and Thornton (1966) These investigators have utilized a design where the same subjects were exposed to SD on one occasion and confinement with some perceptual stimulation on another occasion In the Zuckerman group the duration was 8 hours and in the Persky group it was 24 hours In the 8 hour group there was some evidence of greater arousal in the SD condition as evidenced by greater increases in anxiety measured by the MAACL checklist and higher adrenal hormone levels (17 ketogenic steroids and 17 ketosteroids) There was also evidence of greater primary process thinking in SD using a group of Myers question naire scales However, the tedium stress factor in these scales as well as interview stress measures did not differ after the two conditions The results on the Myers scale are similar to those obtained by Zubek and Mac Neill (1967) In the 24 hour study there were no significant differences be tween SD and recumbent control conditions although the subjects in both conditions had higher adrenal hormone outputs than on an am bulatory control day

The major source of subjective stress which is produced by SD or PD appears to stem from the loss of contact with reality which results in a confusion of internal and external sensations an increase of primary process thinking and disorientation in space and time The anxiety and tedium stress experiences produced by PD seem to be a function of the confinement in an unusual environment The effect of confinement and PD seem to be additive in the case of subjective thinking difficulties This lat ter finding is similar to the finding by Zuckerman Albright Marks and Miller (1962) based on verbalizations after 6 hours of SD

Zubek has also compared his immobilized recumbent and ambula tory groups on behavioral and EEG measures Many of the intellectual and perceptual measures which were impaired by SD or PD were also impaired by immobilization or recumbent confinement Impaired per formance on tests of recall and recognition and reversible figures occurred as a result of immobility alone whereas deficits in verbal fluency space relations and color discrimination were produced by the combined ef fects of restricted motor activity and the recumbent position On one measure visual vigilance the immobilized subjects performed better than the other two groups Immobilization did not produce as wide a range of deficit as PD but much of the effect of PD may be due to immobilization

Similarly on EEG immobilization has been found to effect a sig nificant decrease in occipital lobe frequencies but the effect is not as great as that found in SD groups (Zubek & Wilgosh 1963 Zubek & Mac Neill 1966)

Zubek (1963a) has also found that physical exercises during PD re sulted in significantly less impairment in intellectual and perceptual motor tests and less EEG change than in PD subjects not required to exercise during the one week period However about the same proportion

(two thirds) of this group quit before the end of the week as in non exercise SD and PD groups Courtney, Davis and Solomon (1961) compared subjects in SD who were required to exercise with large body movements and another group who just made small finger movements on signal No differences were found on checklist and postisolation stress reports Although exercise seems to reduce some of the cognitive, perceptual, and EEG impairment during SD or PD, it does not seem to reduce the stress effects

Confinement and relative immobilization emerge from these studies as crucial variables in SD The ambulatory control for SD is not sufficient to separate these effects from those of SD itself

Contacts with Experimenters and Social Isolation

Social isolation has been shown to produce some of the effects found in SD experiments (Walters & Parke, 1964) Subjects in most SD experiments are not entirely socially isolated because they know they can be heard through the intercom system even if there is little actual communication Many subjects reassure themselves on this point before they go into isolation In some experiments the isolation is interrupted for feeding or toilet needs or to administer tests What effect do these interruptions, with their social and sensory stimulation, have on the subject?

The Boston group ran three studies in which this factor of severity of social isolation was varied This group used the "iron lung respirator as the mode of confinement In the first group (Wexler, Mendelson, Leiderman & Solomon 1958) of 17 subjects, an observer was in the room nearby taking notes and attending to the subject's requests for food water, elimination, and comfort In the second group (Mendelson et al, 1960) of 10 subjects, the subject never saw the observer except for elimination They were self fed and verbalizations were recorded automatically In the first group 71 percent of the subjects remained in the experiment at the end of 8 hours and 35 percent remained 24 hours In the more severely isolated group, only 40 percent of the subjects remained 8 hours and only 10 percent remained 24 hours In a third study (Davis McCourt, Courtney, & Solomon 1961) 10 males were placed in isolation in pairs and allowed to converse Although there was not a great deal of communication between the strangers 90 percent were able to stay for 10 hours as compared with 30 percent of the severely isolated group in the second experiment However, social stimulation may not always facilitate endurance When Davis placed married couples in the twin respirators only 1 of 11 couples remained for the 10 hours Whereas the male strangers perceived the situation as a competitive one (to see who would last the longest), the married couples discussed their discomforts and supported each other s decision to terminate The social stimulation in the married couples resulted in fewer hallucinations somatic complaints and mental

cloudiness The male strangers isolated together had reactions more comparable to males in SD alone The authors concluded that social contact ameliorated but did not eliminate the effect of SD

The ameliorating effect of social stimulation probably depends upon the compatibility of the partners who share the experience Altman and Haythorne (1965) studied two man groups isolated together for 10 days Half of the groups were rated as compatible using personality test scores while the other groups were rated as incompatible When the groups were compared on the Myers Post Isolation Questionnaire the compatible pairs had stress scores close to those found in nonisolated ambulatory controls the noncompatible pairs had stress scores equivalent to those found in 4 to 7 days SD subjects The result confirms something known to many unhappy couples togetherness with someone who is incompatible is as bad as being alone

Zubek (1964b) ran a group of 16 subjects in a one week PD experiment to see if eliminating testing intrusions would increase hallucinations and post isolation perceptual effects which were absent in his former groups Three quarters of this group endured the week of PD which is about the same proportion (67 to 73 percent) found in their other SD and PD groups Hallucinations and post isolation perceptual effects were just as rare as in the former groups

Experiments to date have not adequately distinguished between confinement social isolation and PD Experiments now being carried on in the labs of Myers (Naval Medical Research Institute) and Zuckerman (A Einstein Medical Center) will enable us to compare the effects of (1) free ambulatory conditions (2) confinement with social and perceptual stimulation (3) confinement with perceptual stimulation only and (4) confinement with social and perceptual deprivation Comparisons of 1 and 2 will enable us to appraise the role of confinement comparisons of 2 and 3 the role of social isolation and comparisons of 3 and 4 the role of perceptual isolation

Zuckerman Persky Link & Basu (1968a) have obtained the following results in a study making these comparisons of conditions (1) most of the stress in SD including adrenal medullary responses and questionnaire reported stress is produced by confinement even without sensory or social isolation (2) social isolation even without sensory deprivation produces more contemplative responses dreams memories and reports of inefficiencies of directed thinking than confinement with social stimulation (3) sensory deprivation produces more reports of visual and auditory sensations (imagery) dreams and feelings of unreality than social isolation Another effect specific to SD is the increase in anxiety as measured by the Zuckerman Lubin (1965) Multiple Affect Adjective Check List The mean change in anxiety in social isolation simple confinement or ambulatory control conditions is close to zero The increase in anxiety in the SD

condition is highly correlated with the feelings of unreality, reported visual sensations dreams and complaints of inefficiencies of directed thinking In other words, confinement to a bed in a small cubicle for 8 hours produces generalized stress relative to a normal environment Social isolation adds to this some increase in unstructured cognitive activity but not enough to produce significant amounts of anxiety in most subjects Sensory deprivation adds the feeling of loss of touch with reality and 'primary process phenomena such as intense images (sometimes hallucinations) and dreams which result in increased anxiety in a significant number of subjects

Suedfeld, Grissom and Vernon (1964) demonstrated that SD impaired verbal productivity in response to an open-ended auditory projective test, while social isolation, without SD, increased productivity The effect was replicated in the first session of a second experiment (Suedfeld, Vernon Stubbs, & Karlins 1965) but was diminished in a second isolation session Suedfeld has interpreted these differences between SD and social isolation in terms of a heightened social drive produced by social isolation which is outweighed by a cognitive decrement produced by SD Subjects in both conditions complain of the inefficiency of their thinking (Zuckerman et al, 1966, Zuckerman Persky, Link, & Basu, 1968b), but the actual inefficiency in the Suedfeld experiments is found only in the SD condition Perhaps the heightened anxiety in the SD condition interferes with their verbalization or perhaps a minimal level of stimulus input is necessary to maintain directed thinking Whatever the answer, the increased verbal productivity of the socially isolated subject dramatically underlines the relative muteness in the SD subject. But this does not mean that cognitive activity is not going on in the SD subject The type of activity which is occurring may simply be harder to verbalize just as dreams are quickly forgotten

Duration of Isolation

Experiments involving SD or PD have ranged from 5 minutes to 2 weeks Some of the contradictory results in the literature might be a function of the different durations used Just as the dosage effects in drug experiments must be appraised before the drug effects can be adequately tested, the duration effects of SD on different kinds of response must be known in order to study effectively these relationships

An examination of endurance effects (Zuckerman, 1964b) indicates that in bed-confinement SD experiments where the subjects know the limit of the experiment, about 90 to 100 percent of male subjects can endure isolation for one day A small number quit on the second day, but the third day seems to be the critical period with one quarter to one third of the subjects quitting by this time Most of the subjects who stay for the third day go on to the end whether it is 4 7 or 14 days

Body movement which has been shown to predict quitting (Smith Murphy & Myers 1962) shows an initial adaptation effect during the first 3 hours of SD (Zuckerman et al 1966) followed by an increase to a maximum at 12 hours and then by a decrease during the hours of sleep with a secondary increase early the next morning A control confinement group provided with television and radio showed significantly greater movement than the experimental SD group during the first 8 hours of SD but the SD group had significantly more movement during the last 8 hours of the 24 hour period (Figure 3–3) The diurnal cycle is reflected in the greater amount of daytime than nighttime movement and the daytime movement shows a progressive increase over 4 days of SD (Figure 3–4)

GSR measures of skin conductance and nonspecific fluctuations in skin resistance EEG frequencies and amplitudes have been interpreted as measures of arousal or activation of the central nervous system Skin con ductance was found to fall indicating decreased arousal in the 2 hour SD study of Cohen Silverman and Shmavonian (1962a) However Zucker man found a pattern of rising skin conductance in 3-hour (Zuckerman Levine & Biase 1964 Biase & Zuckerman 1967) and 8 hour (Zuckerman et al 1966) SD experiments Vernon McGill Gulick and Candland

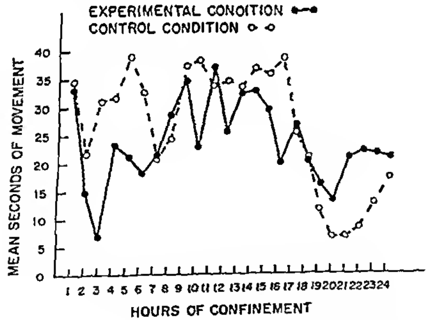

FIGURE 3–3 Body movements as a function of durat on (hours) and ex perimental (SD) and control (social isolation) conf nement cond t ons

SOURCE Reprinted by permiss on from H Persky M Zuckerman G K Basu, & D Thornton Arch gen Psychiat., 1966 15 499–505

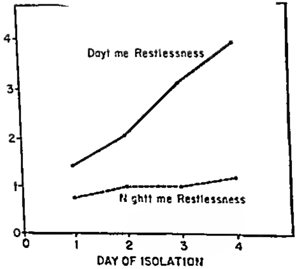

FIGURE 3–4 Body movements as a function of duration (days) and daytime versus nighttime activity The units in the ordinate refer to the restlessness rate in movements per minute

SOURCE Reprinted by permission from T I Myers D B Murphy S Smith & S J Goffard, HumRRO Tech Rept No 66–8 June 1966

(1961) found that skin conductance continued to increase in 24, 48-, and 72 hour groups

Cohen Silverman and Shmavonian (1962a) found that N-S GSRs EEG and Pulse Rate indicated decreasing evidence of activation during 2 hours of SD The data of Zuckerman et al (1966) on N S GSRs heart rate and breathing rate indicate a decreasing arousal during the first 4 to 5 hours of SD or in the control stimulation condition (Figure 3–5) However, the rising skin conductance during this period of time is in conflict with the decreased arousal trend During the sixth and seventh hour there are some secondary increases in most of these measures but they do not reach the high levels found in the baseline periods just after the subject was put in the room and when he was anticipating SD

Figure 3–6 shows the level of arousal as reflected in the EEG data during the first hour of SD (Zuckerman & Hopkins 1966) Most subjects show a tendency to move from a level of high initial alertness to a sleep pattern during this first hour Subjects who reported no visual sensations (no RVS) or made few reports of any kind were especially prone to fall asleep by the end of the hour 60101

Nagatsuka and Kokubun (1964) studied EEG GSR and Heart Rate responses during 48 hours of SD All measures reflected a diurnal cycle, they were lowest during the midnight to morning period and highest during the late afternoon and early evening period EEG records revealed neither very high nor very low activation during the 48-hour period

Zubek (1964a) examined the EEG changes in ten subjects who stayed in PD conditions for 2 weeks He found a progressive decrease in mean occipital lobe frequency over this period of time During the first week the slowing was .52 cps and during the second week another loss of 1 11 cps occurred The net drop was 1 63 cps The effects during the second week

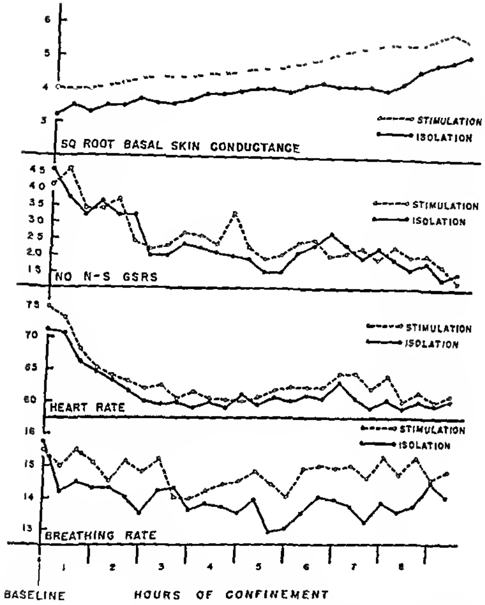

FIGURE 3–5 Mean physiological scores as a function of duration (hours) and confinement conditions isolation (sensory deprivation) and stimulation (social isolation)

SOURCE Reprinted by permission from M Zuckerman, H Persky T R Hopkins, T Murtaugh G K Basu & M Schilling, *Arch gen Psychiat.*, 1968 14 356–365

were twice as great as those during the first week After PD, the mean EEG frequencies began to increase but even after 10 days they were still .51 cps below the pre PD level Correlated with the magnitude of EEG changes were motivational losses such as inability to study or engage in purposeful activity

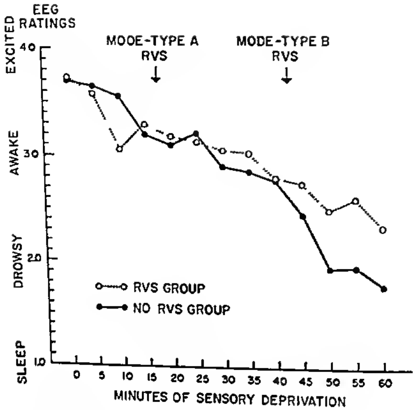

FIGURE 3–6 Mean EEG arousal ratings for subjects reporting visual sensations (RVS Group) and subjects not reporting visual sensations (No RVS Group) as a function of duration during the first hour of sensory deprivation

SOURCE Reprinted by permission from M Zuckerman & T R Hopkins *Percept mot Skills* 1966 22, 447–459

Zubek's findings indicate that long term isolation produces a gradual decrease in C.N.S. activation in awake subjects. Since this decrease in EEG frequency is associated with motivational losses it may be considered a negative sign. Two weeks of PD may be approaching some kind of critical phase where the "sensoristatic" (Schultz 1965) functioning of the reticular formation may break down, leading to an adaptation at a lower level of CNS activity and behavioral alertness.

Zuckerman and Haber (1965) found little change in rate of operant response for visual and auditory reinforcements during the first 2 hours of SD. During the third hour there was a significant increase in response rate for visual reinforcement. Jones (1964a) has shown response rates for visual reinforcements increasing as a function of the duration of prior SD up to 48 hours.

Pollard Uhr and Jackson (1963a) Vosberg Fraser and Guehl (1960) and Zuckerman Albright Marks and Miller 1962) have all noted a decreasing amount of spontaneous verbalization with successive hours of short term isolation Zuckerman et al (1962) found that the percentage of subjects reporting visual and auditory sensations decreased during 6 hours of SD (Figure 3-7) The mean proportion of the verbalizations that indicated anxiety and complaints of confinement showed marked increases during the fifth and sixth hours of SD

The Myers (1962) Post Isolation Questionnaire and the Zuckerman Lubin (1965) MAACL have been used in a number of studies varying in duration from 1 hour to 7 days Table 3-1 shows the results on the three primary factor scores of the Myers questionnaire There is little change in Factors 1 and 2 between the 8 and 21 hour SD experiments The 96 and 168 hour experiments reflect somewhat higher levels than most of the 8 and 21 hour experiments, but on Factor 1 the differences are not consistent For instance the values obtained on Factor 1 Tedium Stress are almost identical in the Zuckerman 1 day study and the Zubek 7-day study The results are more consistent for Factor 2 which includes Reported Visual Sensations Body Image Changes and Feeling of Unreality Scales On this factor the 4 and 7 day studies produce consistently higher Unreality Stress than the shorter studies However on both factors 1 and 2 there is little difference between 1 day and 7-day studies Factor 3 Positive Contemplation also shows the increase between the 8 to 24 hour studies It is surprising that this factor which seems to measure adaptive response increases with duration This may be a response set tendency in the questionnaire or may reflect the increasing variety of positive as well as negative reactions during long periods of SD

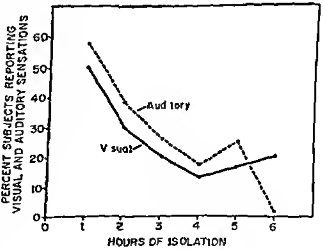

FIGURE 3-7 Percentages of subjects reporting visual and auditory sensations as a function of duration (hours) of sensory deprivation

SOURCE Reprinted by permission from M Zuckerman R J Albright C S Marks & G L Miller *Psychol Monogr* 1962 *76*, *No 30* (Whole No 549)

TABLE 3-1 Mean Scores on Myers Questionnaire Factors

Study	Exp Hours	SD or PD Conditions Factors[1]			Confinement Conditions Factors[1]			Ambulatory Control Conditions Factors[1]		
		1	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*3*
Zuckerman	8	48	24	24	46	16	22			
Persky	24	52	23	23	37	14	18			
Suedfeld	24	43	24	38				22	11	24
Myers	24	31	18	32	22	12	24	27	16	35
	96	58	37	48				27	11	33
	96	65	44	44				31	14	33
Zubek	168	54	38	48	38	27	44	22	12	31

[1]Factor 1 = Tedium Stress
Factor 2 = Unreality Stress
Factor 3 = Positive Contemplation

Studies using the MAACL Anxiety measure have covered a shorter range of durations than those using the Myers Questionnaire Table 3-2 shows the mean Post SD scores in eight groups of males and females in experiments ranging from 1 to 24 hours There is some evidence of a slight increase between 1 and 24 hours in anxiety scores on this instrument but the over all increase is not impressive When comparisons were made on pre post difference scores between SD and confinement control groups the differences were not significant in the 3-hour experiments (Biase & Zuckerman 1967) but were significant in the 8-hour experiment (Zuckerman et al 1966) Differences in the 24 hour group (Persky Zuckerman Basu & Thornton 1966) were not significant because of the higher initial anxiety scores prior to SD and the smaller number of subjects

A few experimenters have administered cognitive tests at various points in time during SD Zuckerman Albright Marks and Miller (1962) tested subjects on free and controlled association after 3 and 6 hours of SD The SD group showed a progressive decrease in verbal productivity during free association while the ambulatory control group increased during the same period In controlled association naming words beginning with a specified letter the SD group did not improve with practice while the control group did The net effect was a relatively increasing paucity of associational productivity in SD over the six hours of SD Bexton Heron and Scott (1954) found a similar result on a word making test The SD subjects showed little gain in correct words made from jumbled letters, from the first test given before SD to the fourth test given after SD

TABLE 3 2 Mean Anxiety Scores (MAACL)

Conditions & Groups	Exp Hours	Males N	Males Anxiety	Females N	Females Anxiety
Sensory Deprivation	24	12	11 0[1]	–	–
Sensory Deprivation	8	17	10 8[2]	12	11 3
Sensory Deprivation	6	19	10 6	25	11 4
Sensory Deprivation	3	12	9 4	12	9 5
Sensory Deprivation	1	58	9 2	22	9 9
Confinement & Social Isolation	24	12	7 9	–	–
Confinement & Social Isolation	8	17	9 7[2]	12	8 7
Confinement	8	12	6 3	12	8 4
Confinement	6	–	–	13	8 2
Confinement[3] & Social Isolation	3	12	7 7	12	10 1
Psychiatric Patients		138	9 7	107	10 7
College Students		44	6 9	31	6 3
Normals		100	5 8	100	6 7
Ambulatory Controls		11	6 5[1]	–	–

[1]Same subjects in three conditions—24 hour experiment
[2]Same subjects in two conditions—8-hour experiment
[3]Light but no sound

During the same period the control group showed a marked increase in performance Three days after SD both groups performed at the same level Errors in the control group did not change during this period of time but errors in the SD group increased steadily from pre-SD to 48 hours of SD Three days after SD both groups performed at the same lower level of error The post SD results tend to indicate that the SD subjects were benefiting from the learning during SD even though it was not reflected in their performance during SD An increasing general drive level or arousal could account for the increasing errors in the SD group

Zubek et al (1962) tested the PD subjects once a day for 7 days on a battery of cognitive tests The maximal difference between the PD group and the control group and the lowest point in the PD group on Verbal Fluency and Number Facility occurred on the first day of isolation Abstract Reasoning and Recognition deficits were maximum on the third day of isolation Other tests varied in their days of maximum effect Zubek noted that on most of the tests there seems to be little or no relationship between the extent of impairment and duration of isolation (1962 p 181)

Obviously the question as to how long a person must be in SD to obtain effects cannot be answered except in reference to specific kinds of effects If one wants to study spontaneously reported visual sensations, 1 hour of SD is probably sufficient If one wants to compare stayers and quitters in isolation, a 3-day or longer duration is necessary unless one uses respirator or water tank confinement If one wants to study gross body movement, a 2-day or longer experiment is necessary Study of the brain wave shifts to the lower frequencies requires at least a 1-day duration and 7 days would be more desirable to get effects As far as physiological and behavioral indices of stress go, the first few hours are an adaptation period for SD and experiments of 3 hours or more are required Significant verbal stress effects relative to ambulatory controls may be elicited on post SD checklist affect measures or questionnaires after only a few hours of SD, but most of these are effects of confinement rather than SD Durations of 6 hours or more seem necessary to produce true SD anxiety Cognitive effects depend on the particular skills Associational and verbal fluency measures seem to be maximally affected on the first day, probably an 8-hour period is sufficient to study them Impairments of the ability to think abstractly may require a 3-day experiment Experimenters should give careful consideration to the duration of their experiment and even invest some time in pilot studies before they conclude that SD does or does not affect X or Y or that personality Type A responds differently to SD than personality Type B

The Effect of Prior Exposure to SD or Confinement

One prominent school of SD research points to the set induced by prior information and the SD situation itself as the source of the unusual reactions to the situation (Jackson & Pollard, 1962) If this view is correct, one might expect that the effects of initial exposures to SD will be much greater than second exposures In fact, an initial exposure to the confinement room even without perceptual restriction, should ameliorate the later reaction to SD or PD

Pollard, Uhr, and Jackson (1963a), ran a group of twenty four subjects in 8 hours of PD twice The two sessions were generally a week apart The number of subjects remaining and the average time of endurance was about the same in the two sessions Considerably less spontaneous verbalization occurred during the second session In the first session, there was a significant tendency to underestimate time This tendency was not present in the second session The experimental subjects estimated the speed of movement more slowly than the controls after both sessions and the differences between sessions were not significant Self ratings on affect adjectives such as "calm" and "tense" showed no change from the first session to the second session and after both sessions the SD subjects tended to rate their mood in more negative terms than the controls The main find

ing in this experiment was the reduction in the spontaneous reports of SD phenomena in the second session The other types of measures used and the endurance time itself did not support an adaptation interpretation

Shurley (1966) provides some data on repeated runs of five subjects in water tank confinement Generally subjects showed increasing endurance times on subsequent runs

Leiderman (1962) used a design counterbalancing conditions and sessions The pilot study used six subjects in four conditions on four sessions The more extended study used sixteen subjects with two conditions in two sessions In the pilot study heart rate was highest in the first of the four sessions for five of the six subjects Reports of discomfort and somatic complaints were highest in the first session In the larger study there were no sessions effects for imagery Galvanic Skin Potential levels fell and heart rate responses to stimulation rose during the second session indicating that the process of adaptation had not been completed by the second session

Zuckerman et al (1966) used two conditions 8 hours of SD and 8 hours of confinement with stimulation in two sessions counterbalanced over subjects Primary Process and Stress Response scores were derived from Myers Post Isolation Questionnaire The Primary Process score (Reported Visual Sensations Body Image Changes and Feelings of Unreality) showed the effects of conditions being higher after the SD condition The Stress Score showed a significant effect for sessions more stress was reported in the questionnaire after the first session than after the second session There was little effect of conditions on this score Persky Zuckerman Basu and Thornton (1966) extended this design to a 24 hour experiment Using Myers definition of the stress factor in the questionnaire the stress score again showed a significant sessions effect being higher after the first than after the second session The conditions effect was not significant In this experiment the change in the Depression scale score on the MAACL also showed a significant sessions effect The results would tend to indicate that much of the verbal stress response to 8- or 24-hour SD is a function of the strangeness of the first confinement experience In both of these experiments none of the autonomic or hormone measures used to assess stress effect showed a significant sessions effect

Zubek et al (1962) ran four subjects in a 1 week PD experiment who had been used a year earlier in a 1 week SD experiment Three of the four subjects reported that the second experience was easier to endure and a comparison of the performance of the four subjects with nonrepeaters indicated better functioning of the repeaters on 9 of 12 tasks

Suedfeld Vernon Stubbs and Karlins (1965) found that 24 hour SD produced a significant decline in verbal productivity in a story telling task In a second SD session the subjects showed less decline in productivity and the net change was not significant

The general findings indicate that verbal stress reactions to SD or PD are markedly reduced if the SD session has been preceded by a prior experience of SD or even one of confinement in the experimental situation without SD Other stress indices such as endurance, behavioral deficits, and hormone measures do not consistently show this adaptation effect. The subjects may be just as stressed by a second SD experience, or one preceded by a single confinement experience, but they tend to talk about it less or are less aware of the bodily stress

Sets Produced by Conditions and Instructions

In comparing the endurance in experiments where subjects are told the time limit of the experiment, and those in which the time of stay is left up to the subject, Zuckerman (1964b) noted the greater endurance in the former type of experiment In Myers and Zubek's SD and PD experiments about two thirds to three quarters of the subjects stayed to the bitter end regardless of whether the goal was 4 days, 7 days, or 14 days In contrast, none of the male subjects in the Smith and Lewty experiment stayed more than 2 days The time limit was left indefinite in the latter experiment Differences between populations could account for this difference in endurance Francis (1964) compared the endurance of subjects told that they would stay 3 hours in underwater confinement and another group told to 'stay as long as possible Half of each of these groups were told to say nothing and were given no indication of the passage of time, the other half were told they could communicate to E and were informed of the time every 20 minutes None of the main effects in this study were significant, but the interaction of definiteness-indefiniteness and time information was significant. As expected, the group told the period of confinement and kept informed of the passage of time showed the best endurance However, the group that was given an indefinite time limit and not informed of time passage was the second best in endurance, rather than the worst as was expected The most abrupt quitting was found in the group given an indefinite endurance set but informed of the passage of time

The effects of the suggestive information given the subject in preexperimental instructions was studied by Pollard, Uhr, and Jackson (1963a) Two groups of subjects were given neutral sets with no mention of sensory deprivation or its possible effects These groups were given 8 hours of PD A third group was told about some of the common PD effects and subjected to only 3 hours of PD A nonconfined control group was used for comparisons The group given a set for PD effects reported more of these effects and generally made more verbal reports of all kinds during 3 hours of PD than the group given the neutral set reported during 8 hours of PD Many of the effects reported were said to be bizarre and unusual However the positive set group did not differ markedly from the

neutral set group on self ratings or on behavioral tests given after PD The results are similar to those which involved comparisons of first and second sessions The major effects of set were on the quantity and quality of spontaneous reports made during the PD session

Leon and Arnhoff (1965) compared the postisolation interview reports of subjects in three groups (1) given no set but led in blindfolded and told to lie quietly (2) told about the possible effects of PD and told that these effects sometimes occur and (3) told about possible effects and told that it was expected that they would also experience these effects The group told to expect the effects reported more isolation and imagery disturbance than the other two groups The uninformed group tended to err more in time estimation The study tends to show that permissiveness of PD effects encourages subjects to report these effects Actual information about PD effects appears to be less important than the expectation of having the effects occur The group informed that the effects sometimes occur actually reported the least disturbance while the group told to expect the effects reported the most disturbance The uninformed group was intermediate in reported disturbance

Murphy (1966) used the Pollard Uhr and Jackson (1963a) suggestions in comparisons between a group given the set a group given a more neutral set derogating the reliability of previous research and a control group given no set The dependent variables were the maturity or immaturity of cognitive functioning as assessed by interpretations of ambiguous sounds Although the authors concluded that explicit suggestion augmented the effects of SD in producing less mature performance the fact is that all groups showed a decrease in mature functioning and *t* tests between mean change scores yielded no significant differences between groups

Orne and Scheibe (1964) conducted an interesting study in which they varied the preliminary procedures but kept the actual experimental conditions constant The condition was a social isolation one with the subject confined in a well lighted room for four hours One group was greeted with a ritualistic medical type atmosphere complete with release forms white coats emergency tray and other indications that the procedure might be dangerous or upsetting Subjects in the control group were told they were in a control group and the drama used with the experimental group was absent Various cognitive and perceptual tests were administered before and after social isolation and a postisolation open-ended interview was used to obtain subjective reactions Four of the behavioral tests differentiated the groups significantly In 13 of the 14 comparisons the set group did more poorly than the control group Significantly more of the set group reported Intellectual Dullness and Restlessness Borderline significant differences were found for reports of Affective Unpleasantness and Spatial Disorientation No significant differences were found on

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Leon and Arnhoff (1965) compared the postisolation interview re ports of subjects in three groups (1) given no set but led in blindfolded and told to lie quietly (2) told about the possible effects of PD and told that these effects sometimes occur and (3) told about possible effects and told that it was expected that they would also experience these effects The group told to expect the effects reported more isolation and imagery disturbance than the other two groups The uninformed group tended to err more in time estimation The study tends to show that permissiveness of PD effects encourages subjects to report these effects Actual informa tion about PD effects appears to be less important than the expectation of having the effects occur The group informed that the effects some times occur actually reported the least disturbance while the group told to expect the effects reported the most disturbance The uninformed group was intermediate in reported disturbance

Murphy (1966) used the Pollard Uhr and Jackson (1963a) sugges tions in comparisons between a group given the set a group given a more neutral set derogating the reliability of previous research and a control group given no set The dependent variables were the maturity or immaturity of cognitive functioning as assessed by interpretations of ambiguous sounds Although the authors concluded that explicit sugges tion augmented the effects of SD in producing less mature performance the fact is that all groups showed a decrease in mature functioning and *t* tests between mean change scores yielded no significant differences between groups

Orne and Scheibe (1964) conducted an interesting study in which they varied the preliminary procedures but kept the actual experimental conditions constant The condition was a social isolation one with the sub ject confined in a well lighted room for four hours One group was greeted with a ritualistic medical type atmosphere complete with release forms white coats emergency tray and other indications that the procedure might be dangerous or upsetting Subjects in the control group were told they were in a control group and the drama used with the experimental group was absent Various cognitive and perceptual tests were adminis tered before and after social isolation and a postisolation open-ended in terview was used to obtain subjective reactions Four of the behavioral tests differentiated the groups significantly In 13 of the 14 comparisons the set group did more poorly than the control group Significantly more of the set group reported Intellectual Dullness and Restlessness Border line significant differences were found for reports of Affective Unpleasant ness and Spatial Disorientation No significant differences were found on

Perceptual Aberrations, Anxiety and Fears, and Irritability The preexperimental environment used by Orne was more extreme than the typical SD environment No one has ever had an "emergency tray" in view of subjects The procedure was calculated to frighten the subjects and it apparently succeeded in doing this In view of Orne's (1962) emphasis on the ways in which experimenters as well as subjects, may bias the outcome of experiments in the desired directions, it is surprising that he did not use a more objective method for appraising the subjects' verbal reactions Although a statement is made that the post isolation interview was conducted in exactly the same manner for all subjects, there is no indication of how this possible source of bias was avoided in the open-ended interview and the subsequent "clinical evaluations' made of the subjects' behavior and remarks Assuming that there was no such bias the experiment might indicate that some of the atmosphere accompanying SD experiments could create some of the stressful subjective responses to these experiments, and could even affect performance on objective tests

Zuckerman and Cohen (1964b) used a control group given a minimum amount of set in the instructions with three experimental groups each group given increasing amounts of set for SD effects (e g, hallucinations and odd feelings) The last two groups were also given placebos which were presented as drugs which would enhance these effects All subjects were exposed to one hour of SD Only the reports of the least meaningful types of visual sensations were found to increase with increasing suggestion The more meaningful and structured types of visual sensations as well as stress reports rated by two judges from structured post-SD interviews, and anxiety scores on the MAACL checklist, were not significantly affected by the different preexperimental sets These results are at some variance with those of Orne One possible source of difference is that Orne's suggestions of stress effects were created indirectly by a rather extreme type of atmosphere In this experiment, the suggestion was varied more directly in the statements made to the subjects, although the placebos given to the subjects could have enhanced the suggestions

Short and Oskamp (1965) also have varied set, contrasting the effects of Jackson and Kelly's (1962) high suggestion instructions and placebo with low suggestion instructions These authors did not find the great effects of suggestion in a one hour PD experiment that Jackson and Kelly did Their results were more comparable to the results of the Zuckerman and Cohen (1964b) study showing only minimal effects of suggestion

Although there is little question that set may influence some of the SD effects the exact set conditions which affect SD response have not been delineated by the experiments The failure of a second experiment by Pollard, Uhr, and Jackson (1963b) to demonstrate effects of set, even on the quantity of verbal reports raises more questions about the operation of this variable The sets which subjects bring to the experiment could be

more important than the sets which the experimenter produces This type of set more closely related to the subject s personality will be discussed in a later section One of the important and obvious effects of set is to encourage or discourage reporting of experiences during and after the experiment

SUBJECT VARIABLES

At the outset of this chapter the ambiguous nature of the SD experimental situation was described and the point was made that subject variables were bound to play an important role in this live in inkblot Eight years of observation of subjects in SD has convinced this investigator of the importance of individual differences in this situation Some confirmation of the strength of this clinical observation was found in the study by Zuckerman et al (1966) where the same subjects were exposed to two conditions SD and confinement without SD Subjects responses on 30 autonomic endocrine checklist questionnaire and interview variables were studied Significant differences ($p < .05$) attributable to conditions (SD vs Social Isolation) were found on 5 variables significant sessions effects (1st vs 2nd session) were found on 2 variables significant correlations between the subjects responses to one condition and their responses to the other conditions were found on 15 variables Personality measures which correlated with the subject s responses to one condition usually predicted his responses to the other condition as well

Volunteering Selection

What kind of subject volunteers or does not volunteer for a SD experiment? Myers Murphy Smith and Goffard (1966) compared volunteers and nonvolunteers from their army group Nonvolunteers were older composed of a higher percentage of draftees and had lower combat aptitude scores Despite the fact that they were not regular army they followed the old army adage about never volunteering The nonvolunteers had higher scores on the following MMPI scales Depression Psychopathic Deviate Hysteria and Psychasthenia The latter two differences were of borderline significance On the EPPS scales the volunteers were higher on N Change while the nonvolunteers were higher on N Aggression Both Short and Oskamp (1965) and the Myers group found no differences between volunteers and nonvolunteers in the incidence of reported sensations during short periods of isolation

Zuckerman Schultz and Hopkins (1967) compared student volunteers on the Sensation Seeking Scale (Zuckerman Kolin Price & Zoob 1964) In the sample of female undergraduates the volunteers for SD and hypnosis experiments were significantly higher on this scale of need for

excitement and sensory variation. In one sample of male undergraduates, the difference was not significant for SD volunteering. The authors collected results in additional samples where they found that male volunteers were significantly higher on the SSS; the difference for female volunteers vs. nonvolunteers was of borderline significance ($p < .10$). Although there was a lower percentage (68 percent) of first borns in the Zuckerman, Schulz, and Hopkins (1967) female sample volunteering for SD than in the nonvolunteers, the difference was not significant. Suedfeld (1964c) reported a high percentage (79 percent) of first borns among male volunteers for SD but this percentage was about the same as the percentage of first borns volunteering for an experiment in social interaction (Capra & Dittes, 1962).

Myers, Murphy, Smith, and Goffard (1966) found that most of their subjects volunteered either to contribute to science or to test their own reactions. No monetary rewards were offered in this experiment. Wexler, Mendelson, Leiderman, and Solomon (1958) found that five of 17 subjects volunteered to test their reactions while most of the others volunteered for the money. It is interesting that four of the five self-testers quit the experiment before 8 hours, while only one of the 11 subjects who volunteered for the money quit before this time. The self-testing motivation may represent a counterphobic tendency in many subjects.

Subjects' Expectations

Most subjects expect SD to be stressful, and some expect to have "hallucinations" or other peculiar experiences. Biase (1967) showed an SD room and apparatus, read SD instructions to subjects, and had them take the Zuckerman-Lubin MAACL, checking the adjectives which they thought would describe the way they would feel after three hours in SD. Anxiety expectation scores were significantly higher than the scores obtained in other groups after 3 hours of actual SD. Females had significantly higher anticipation anxiety scores than males. These data fit the autonomic data obtained by Zuckerman et al. (1966) which show a higher degree of arousal in the baseline period in the isolation room prior to SD, than the mean arousal effects during SD. In small samples of quitters, this is not the case; they typically show a sudden increase in arousal just prior to quitting. These data refer to autonomic measures of immediate arousal, rather than long-term measures such as skin conductance and body movements which tend to show a cumulative effect of isolation, increasing above the baseline.

Myers, Murphy, Smith, and Goffard (1966) conducted a study of expectation by letting a group of subjects view the isolation cubicles, and read descriptions of the procedures. The subjects did not predict the relative magnitude of specific effects described in the postisolation questionnaire. In general, they tended to underestimate the number of areas of

concern to subjects in 4-day SD They were fairly accurate in predicting the general level of stress as measured by a mood checklist Perhaps the greater accuracy of subjects in predicting stress level on a mood checklist in the Myers study as compared to the Biase (1967) study was due to the longer duration of the Myers study (4 days as opposed to 3 hours) It is possible that many subjects rating the stressfulness of SD do not differentiate between short and long term SD

Reed (1962) compared the effects of a short period of 40 to 60 minutes on two groups of subjects Group A who expected that SD effects would be slight or would only occur after several days of SD and Group B who expected that the effects would be intense and would occur within the first hour of SD

Group B the high-expectancy group reported significantly more visual and auditory sensations of an unstructured variety (e g changes in brightness and intensity of white noise) body image disturbances changed time sense anxiety and unpleasantness

The results are similar to those reported by Zuckerman and Cohen (1964b) in a previously described experiment where only the least structured and meaningful types of visual sensations were affected by the experimentally induced sets Apparently set produces a heightened alertness to minor peripheral sensory changes However the mood changes found by Reed were not found in the Zuckerman and Cohen (1964b) study Zuckerman and Cohen (1964b) and Zuckerman and Hopkins (1966) found no relationship between the subjects expectations of hallucinations reported before the SD experience and the experimental suggestions and subsequent incidences of reported visual sensations

It is clear that the subject who expects intense effects may be looking for such effects and he may find them in normally ignored sensations from his receptors and body but in general the subject s expectations are poor predictors of his actual responses to SD Most subjects expect more than actually happens in short-duration SD studies

Sex Differences

Smith and Lewty (1959) compared the time to quitting of 11 women and 9 men in PD The social and perceptual isolation in this experiment was interrupted four times a day for testing and feeding The termination of the experiment was left up to the subject The men stayed an average of 29 hours while the women stayed for an average of 49 hours The subjects in this experiment were British hospital workers ranging in age from 20 to 55

Pollard Uhr and Jackson (1963a and 1963b) found that American male undergraduates stayed about 7 hours on a first and 8 hours on a second PD experience while females averaged about 5¼ hours on both PD

occasions Thus in the American short term experiment, males showed greater endurance Pollard and his co-workers found no significant sex differences in number of spontaneous reports during PD or behavioral tests and self ratings after PD Their data reveal no significant sex differences in reported visual or auditory sensations

The data of Davis McCourt, Courtney, and Solomon (1961) may support the findings of Pollard since more pairs of married couples quit PD earlier than pairs of male strangers Both Pollard and Davis indicate that females seem more ready to admit their discomfort than men and are less likely to view the situation as a test of their adequacy

Arnhoff and Leon (1963b) compared the responses of 19 males and 17 females to a 2 hour SD experience There were no significant sex differences on estimation of time reported disturbances on a postisolation interview, or imagery disturbance (hallucinations and illusions)

Reed and Kenna (1964b) compared 14 males and 14 females who were exposed to a very short 20-minute SD period There were no significant sex differences in disturbances of body orientation or body image

Leiderman (1962) compared eight males and eight females in an experiment involving counterbalanced conditions of visual and auditory PD and simple auditory PD each condition lasting 2 hours No significant sex differences were found on imagery reports Galvanic Skin Potential or Heart Rate

Walters Shurley and Parsons (1962) and Walters Parsons and Shurley (1964) compared the verbal responses of males and females to 3 hours of water tank SD During SD males tended to make more stimulus-bound verbalizations (e g comments on water temperatures bodily sensations and discomforts) while females made more non stimulus-bound statements (e g memories daydreams and hallucinatory phenomena) In the post-SD interview significantly more men than women reported being hungry and restless Some of the results of the interview were found to vary with the sex of the interviewers relative to the sex of the subject

Francis (1964) compared the endurance of males and females in 3 hours of water tank SD No significant sex difference on endurance was found

Biase and Zuckerman (1967) studied the reactions of 36 males and 36 females to conditions of total and partial SD of 3-hours duration The authors hypothesized that females would admit more stress on verbal measures while males would show more stress on physiological measures (GSR) Males showed a greater increase in skin conductance than females and females scored significantly higher on a stress score derived from the post SD interview The hypotheses were confirmed on these measures although not on other GSR and verbal measures The males reported more visual sensations of the structured meaningful type but there were no sex differences on other types of reported sensations

The findings in this area are quite mixed The data of Smith and Lewty (1959) and Walters and his co-workers indicate that females adapt better to SD than males The data of Pollard, Uhr, and Jackson (1963a and 1963b) and Davis, McCourt, Courtney, and Solomon (1961) indicate that males show a superior adaptation because of their motivation to "prove themselves" The studies of Arnhoff and Leon (1963b), Francis (1964), Leiderman (1962), and Reed and Kenna (1964b), indicate no sex differences in responses to SD The experiment of Biase and Zuckerman (1967) indicated that females verbalize more stress while males show more physiological arousal to SD Most of the sex differences found in SD experiments are probably a function of sex related sets to admit or deny discomfort Further work is needed on involuntary physiological responses of males and females in SD to see whether there is anything in the basic masculine or feminine personality traits which are related to the ability to be alone, immobile, and deprived of external stimulation

Subjects Personalities

A number of studies contrasting the SD reactions of different personality types, or correlating personality measures and biographical data with SD reactions have been performed Some of these studies have been exploratory, using general personality tests such as the MMPI and EPPS, while others have operated on specific hypotheses relating a particular personality dimension, such as field independence dependence, to SD reactions

Hull and Zubek (1962), Myers Murphy, Smith, and Goffard (1966) Peters, Benjamin Helvey, and Albright (1963), Wexler, Mendelson Leiderman, and Solomon (1958) Wright and Zubek (1966), and Zuckerman et al (1962) related scores on the MMPI and EPPS to measures of stress The first two studies and the Wright and Zubek analysis compared quitters and stayers on these two tests as well as on biographical information The Peters and Wexler studies correlated the personality scales with time spent in isolation, and the Zuckerman study correlated the scales with categories of verbalization during SD and changes on checklist measures of anxiety and somatic complaints

Both the Myers study and Hull and Zubek found that stayers were older and quitters contained a larger percentage of smokers. Hull and Zubek also found that quitters watched television more while stayers read more books

Myers found that stayers were higher on the Affiliation scale of the EPPS The Wexler group found that this scale was correlated positively with endurance, and Zuckerman found that it correlated negatively with increase on the checklist measures of anxiety as well as anxiety and thinking difficulty reports during isolation Peters and his co-workers found a substantial positive correlation ($r = 70$) between Affiliation and rate of

tapping on a telegraph key after SD The correlation with endurance was insignificant Only Hull and Zubek failed to find a significant relation between this scale and some adaptive response to SD

Hull and Zubek discovered that the EPPS Succorance scale was higher in stayers in their SD but not in their PD group Wexler found that this scale was positively correlated with endurance and Zuckerman found it was negatively correlated with body need discomforts complaints of confinement, and thinking and concentration difficulties during SD However in this same study Succorance was positively correlated with complaints of loneliness Only Myers and Peters failed to find a significant relationship between this scale and adaptiveness to SD

Myers found that the scale best predicting staying was the EPPS Deference scale Wright and Zubek found that stayers scored significantly higher on Deference than quitters in one sample but the difference did not hold up in a cross-validation sample Although Hull and Zubek Peters and Wexler found no significant prediction of endurance using this scale Zuckerman found that it was negatively correlated with complaints of somatic discomforts and thinking and concentration difficulties during SD

The general tenor of these EPPS results is that People who need people are not only the luckiest people in the world as the song goes but they adapt better to SD This trend is hardly what one would predict because SD is also a social isolation situation Perhaps the positive social orientation measured by these scales is expressed in the subjects trust that they are not deserted by the experimenter and their desire to please him by remaining in the situation

Myers found two MMPI scales which were higher in quitters Psychopathic Deviate (Pd) and Hypomania (Ma) Although Hull and Zubek could not confirm these results they found that a relevant scale of the Thurstone Temperament Schedule Impulsivity was higher in quitters The Pd Ma combination of the MMPI is typically elevated in asocial character disorders and in the normal range is assumed to measure impulsive antisocial tendencies Grunebaum Freedman and Greenblatt (1960) diagnosed their subjects from interviews before SD The two psychopathic types he found in his sample forced termination of the experiment by removing their earphones or goggles However despite the congruence of the constructs involved in these findings the MMPI vs endurance relationships found by Myers were not replicated in the Hull and Zubek or Wexler studies using the MMPI A more recent study by Zuckerman et al (1966) yielded a large number of significant correlations between the Ma scale and hostile impulsive and stress reactions to both SD and confinement situations The Ma scale also correlated positively with restless movements in both situations The impulsive personality may find SD stressful because of the confinement of activity as much as the perceptual deprivation

Holt and Goldberger (1961) used a large number of personality measures in their two studies of (1) a group of male undergraduate freshmen and (2) a group of unemployed actors In the first study a cluster of measures which the authors labeled acceptance of one s passive feminine side vs masculinity correlated significantly with verbal reactions indicating adaptiveness to isolation The measures included dependency and nurturance needs and esthetic social and other values identified as feminine in our general society At the other end were economic political and mastery values associated with masculinity These results would go along with previous EPPS findings on Succorance Nurturance Deference and Affiliation However in their second sample the authors found that these relationships were generally reversed sometimes significantly so The authors suggest that the presence of a large number of maladjusted homosexual actors in the second group accounted for the reversal In these subjects femininity and passivity was associated with poor ego strength Biase and Zuckerman (1967) attempted to replicate the findings in the first sample using another group of male undergraduates The number of correlations between SD response and personality measures could be accounted for by chance In fact the femininity scale from the MMPI was positively correlated with a few stress measures The existence of any large number of homosexuals in this sample was unlikely However there are also a few isolated findings supporting the hypothesis that feminine males adapt better to SD Hull and Zubek (1962) found that stayers were higher than quitters on a femininity scale Zuckerman et al (1966) found that the MMPI femininity scale was negatively correlated with increases in somatic complaints and time estimates during SD although positively associated with sex and hostility responses

Holt and Goldberger did find that MMPI neuroticism scales Psychasthenia and Hypochondriasis were negatively related to adaptive responses in both samples These scales did not predict endurance in the Myers Hull and Zubek and Peters and Wexler studies but Holt and Goldberger s study was a short-term one of 8 hours and the adaptive response variables were verbalizations indicating adequacy of directed thinking controlled and accepted primary process thinking imagery self stimulation and exploration In the Zuckerman Albright Marks and Miller (1962) study the MMPI F Hysteria Psychopathic Deviate Paranoia and Schizophrenia scales were all significantly correlated with verbalizations of anxiety during the 7 hour SD situation but only the correlation with the Schizophrenia scale remained significant after the anxiety verbalization score was adjusted by dividing it by the total verbalization score Most of these scales were correlated with total amount of verbalization during SD The more neurotic subjects as defined by the MMPI reported more effects of all kinds during SD Peters Benjamin Helvey and Albright (1963) found that pursuit rotor performance after SD was negatively correlated with the F and Sc scales

In the Zuckerman et al. (1966) study, the Taylor Manifest Anxiety Scale was highly correlated with a broad range of post SD interview and questionnaire measures of stress, thinking difficulty, and worry. This scale was also correlated significantly with increases in GSR and Heart Rate response to SD. The MMPI F scale predicted sexual and hostile verbal responses and several autonomic reactions to SD. The general trend of findings in this study indicated that an individual's general psychopathologic tendencies tended to manifest themselves during SD. Generally anxious subjects become anxious, hypochondriacal subjects manifest somatic complaints, and generally impulsive and deviant individuals react with restlessness, sexual fantasy, and hostile or rebellious responses toward the experiment and the experimenter.

Smith and Lewty (1959) gave the Maudsley Personality Inventory to their subjects, and although they did not report a correlation with endurance, a calculation from their raw data revealed a correlation of −.84 between the Neuroticism scale and time endured in SD. Zuckerman et al. (1966) used this scale and found high positive correlations between it and complaints of thinking disturbance in both interviews and questionnaires given after SD.

Wright and Zubek (1966) used the multiple discriminant function technique to see if they could improve on the lack of discrimination using individual *t* tests. A function was derived which correctly classified 76 per cent of the stayers and quitters. The seven most potent variables in the function were the MMPI F and hypochondriasis scales and neuroticism index, the EPPS succorance, and exhibition scales and the Thurstone Temperament Schedule dominant and sociable scales. The stayers were higher on all of these except for the dominant scale. The higher F, hypochondriasis and neuroticism scores of adaptive PD subjects runs against most of the findings of other investigators already discussed. The sociable and low dominant (deferent) characteristics of the stayers do go along with some of the previous findings. However, it must be remembered that none of these variables analyzed separately yielded a significant difference. In a cross-validation, the index correctly predicted the endurance of all 18 stayers but predicted the failures of only four of the 13 quitters. Another index based on Rorschach test variables correctly classified 90.5 percent of the subjects in the initial group but yielded only a chance hit rate of 55 percent in the cross-validation sample.

Tranel (1962) compared ten extraverts and ten introverts on their reactions to SD. The Myers-Briggs Type Indicator was used to define these traits and the subjects' MMPI profiles also reflected the dichotomy. Despite the short duration of the experiment (4 hours), only one of the ten introverts remained to the end, while eight of the ten extroverts endured SD to the end. The group of introverts adhered well to experimental instructions before they quit, while extraverts tended to go to sleep or move

about excessively Introverts engaged in 'stimulus-bound' thought and spoke of a greater amount of discomfort Rossi and Solomon (1966) were unable to replicate any of Tranel s results showing a greater negative reaction of introverts to SD They used the same test to define the personality dimension but a 3 hour instead of a 4 hour SD session Reed and Kenna (1964a) and Reed and Sedman (1964) used the Maudsley Personality Inventory to define Introversion and Extraversion Introverts manifested more depersonalization experiences in a short SD experience of 20 to 60 minutes Extraverts were less accurate in judging time, presumably because they are more dependent upon external cues for orientation Data from the Zuckerman et al (1966) study tended to show that introverts have more autonomic reaction to SD Rossi and Solomon (1965), using the same test of introversion as Tranel found that introverts showed more button pressing for promised time off from isolation, and rated themselves higher on an SD discomfort index Leon and Frank (1966) found negative correlations between the Sociability scale of the Thurstone Temperament Schedule and Isolation and Imagery Disturbance ratings based on a post isolation interview given after two hours of PD All of the positive results on the dimension of extraversion introversion tend to indicate that introverts adapt more poorly to isolation than extraverts The previously discussed data on the Affiliation scale of the EPPS also fits this hypothesis

Silverman, Cohen Shmavonian and Greenberg (1961) and Cohen, Silverman, and Shmavonian (1962a) have used Witkin's (1954) Field Independent Field Dependent personality construct as an independent variable in studies of short term (2 hours) SD The Figure Drawing and Rod and Frame tests were used to separate 35 subjects into Field Dependent and Field Independent subjects (Zuckerman in referring to this dichotomy employed the alternative terms Field Oriented and Body Oriented) The field dependent group was said to show a poorer adaptation to SD than the field independents as indicated by (1) more reported psychological discomfort, (2) a greater incidence of reported visual and auditory sensations (3) more disorganization of thought, (4) greater somatic discomfort, (5) less ability to discriminate somato sensory cues, and (6) more physiological activation as indicated by EEG and GSR measures In a subsequent experiment, the interactions of personality, SD, and sedative and stimulant drugs were tested There are indications that both sedative and stimulant drugs reduced activation in the field dependent subjects relative to placebo plus SD effects The sedatives had little effect, while the stimulant increased activation in the field independents during SD Goldberg (1961) used Rorschach and Figure Drawing scores to define Field Dependence Independence Four extreme field-dependent subjects and four field independent subjects were compared The field-dependent subjects scored higher on a questionnaire scale of maladaptive response to 2 hours of SD in water tank immersion The Rorschach measure was more

predictive of SD tolerance than the Figure Drawing measure A Figure Drawing measure of complexity (Field Independence) was negatively correlated with somesthetic imagery in PD in the Leiderman (1962) experiment

Murphy (1966) used the Embedded Figures Test (EFT) to define field independent and field-dependent subjects This study was discussed previously in the section on Sets Because the field independent subjects showed no significant change on the unstructured cognitive task under neutral conditions while the field-dependent subjects did the author erroneously concluded that field dependents were more vulnerable to the effects of SD The fact that there were no significant differences between the change scores of the groups makes this conclusion very tenuous

Biase and Zuckerman (1967) and Zuckerman et al (1966) also used the EFT measure of Field Dependence Independence in their SD studies This measure failed to predict any significant number of responses to SD in either study These studies did not use extreme scorers on the personality dimension as Cohen and Goldberger did It is likely that the actual correlation between Field Dependence and response to SD is very low if at all significant

Petrie Collins and Solomon (1958) proposed a personality approach based on individual differences in a physiological mechanism sensory satiation Sensory satiation measured by the kinesthetic figural aftereffect was found to be higher in individuals who were best able to tolerate pain but lower in individuals who were best able to tolerate sensory deprivation The theoretical reasoning is that strong satiation of neural response diminishes pain subsequent to an initial painful stimulus but that a strong satiation tendency diminishes the little sensory stimulation that is available in SD A corrollary of this hypothesis is that pain tolerance should be negatively related to SD tolerance

Zubek (1963b) compared the mean pain thresholds of 24 stayers and 12 quitters in PD The difference was not significant and it was the stayers who demonstrated the greater tolerance for pain Peters Benjamin Helvey and Albright (1963) found that subjects with high pain tolerance were able to tolerate SD for a longer period than subjects with low pain tolerance Thus the evidence weighs against the corrollary of Petrie s hypothesis

Some evidence supporting Petrie s hypothesis has recently appeared in a paper by Minard (1966) The author found that kinesthetic aftereffect was negatively correlated with adaptiveness to SD as measured by number of hours of SD volunteered for a hypothetical second experiment and increases in depression on the Zuckerman Lubin MAACL (1965) A similar phenomena in the visual modality disappearance of a luminous frame in a dark room while fixating the center showed the same pattern of correlations with SD reactions Unfortunately the author reported that he

could not obtain significant replication correlations in a second group of 15 subjects The Petrie hypothesis remains unproven although still promising The possibility of variables of set being reflected in both the satiation test and SD situations is an unexplored possibility

Goldberger and Holt (1961a) hypothesized that the capacity for mature handling and freedom of expressing primary process thought would predict adaptive responses to PD In their first study a preexperimental Rorschach measure of effectively controlled primary process correlated positively with the adaptive cluster of verbal responses to isolation and negatively with the maladaptive cluster In their second sample (Holt & Goldberger 1961) of unemployed actors the correlations were not significant and the correlation between primary process and maladaptive response was positive instead of negative Wright and Abbey (1965) analyzed the Rorschachs (Buhler s form) of 21 subjects from the experiment of Zubek et al (1962) The inkblot tests were given after the experiment All seven of the subjects who scored in the high range on the effectively controlled primary process score five of the seven subjects in the middle range and only two of the seven subjects in the low range were successful in completing the week of perceptual isolation A chi square analysis was performed on this 2 × 3 categorization and yielded a significant chi square but the analysis violates the requirement for a minimum expected frequency of 5 in each cell Although the theory relating effective handling of primary process thinking to adaptation to SD is a plausible one the inkblot measures of this trait are difficult to score reliably and may not be valid Podkameni Zuckerman and Ginott in an unpublished study attempted to measure change in primary process scores during SD using the Holtzman inkblot test Significant changes were not found on these measures despite the fact that such changes have been found in SD using the Myers Questionnaire (Zuckerman et al 1966)

Zuckerman Kolin Price and Zoob (1964) developed a Sensation Seeking Scale (SSS) designed to measure individual differences in the need for intense varied stimulation and excitement Zuckerman (1964a) hypothesized that high sensation seekers will not adapt well to isolation despite their eagerness to try new and different situations The eagerness of sensation seekers to try SD was confirmed by Zuckerman Schultz and Hopkins (1967) although there was no difference in one of two samples on the SSS between male volunteers and nonvolunteers for SD In an actual SD and confinement experiment (Zuckerman et al 1966) high sensation seekers were found to be extremely restless using recordings of body movement in conditions of confinement as well as in SD type confinement Three of four quitters in the experiment were among the four highest scoring subjects on the SSS Zubek (1966 personal communication) reports that quitters in a 1 week immobilization experiment scored significantly higher than stayers on the SSS scale The SSS scale seems prom

ising as a predictive measure for restlessness and quitting in any type of confinement situation and is currently being used in a number of SD and confinement studies

Suedfeld (1964a and 1964d) has used a cognitive dimension of personality in conjunction with the "information need" hypothesis to predict responses to SD The dimension is one of abstract vs concrete functioning and is derived from the theory of Schroder, Driver, and Streufert (1967) Abstract individuals are hypothesized to be more highly information oriented and therefore more likely to be stressed by a low information environment (SD) However, if provided with information of a propaganda nature, abstract subjects should be more able to integrate this information within their conceptual structures without the necessity of changing these structures or attitudes Concrete subjects have a more rigid hierarchy of concepts and since they are more dependent upon "environmental anchors" are more likely to be influenced by propaganda in a low input (SD) environment These predictions have been largely confirmed in experiments by Suedfeld (1964a and 1964d) and Suedfeld and Vernon (1966) using a specially designed Sentence Completion Test to measure Abstract vs Concreteness

There is some overlap in the concepts of field independence, sensation seeking and abstract vs concrete personality Zuckerman, Kolin, Price, and Zoob (1964) found a significant correlation between the Embedded Figures Test and the Field Independence and the Sensation Seeking Scale Perhaps all three measures might be more predictive of responses to SD than any one of them since each may have some unique variance which might relate to SD response

There have been few replicated predictions of SD response using personality trait measures although some tantalizing consistencies run through the findings It is difficult to make personality predictions for responses to a situation so loosely structured as SD Many of the failures of replication may be related to differences in experimental procedures and samples Until the situational variables in SD are better defined, it may be premature to undertake personality studies However, one cannot blame us for trying One important point should be made in order to know what we are predicting from personality trait measures, we should use these measures in studies of subjects in social isolation and confinement as well as subjects in SD or PD where perceptual restriction is added to the former two variables

Cultural Differences

An interesting but somewhat neglected area of study is the comparison of subjects from different cultural groups Most SD studies have used American Canadian and British subjects from middle-class highly educated backgrounds One wonders how Buddhist monks, for instance,

would react in SD. Berkowitz (1967) has reported that a group of Thai monks scored very low on the Sensation-Seeking Scale. Even without this knowledge one would predict that any group who practiced withdrawal from social interaction and inner contemplation would adapt well to SD relative to the reactions of representative subjects from a noisy, busy urban environment. Rural vs. urban comparisons within Western societies may also be relevant to this question. But there are other aspects of Eastern culture such as the "face-saving" attitude which might create greater endurance of isolation. All 23 of Kitamura's (1965) Japanese subjects were able to endure 18 hours of PD without quitting.

Peters, Benjamin, Helvey and Albright (1963) compared the reactions of seminary students and officers of the U.S. Air Force. The ministerial students were more highly educated than the Air Force officers which might be a variable producing some of the differences. As a group the seminarians were higher on several traits which have been associated with adaptive response to SD, e.g., femininity, affiliation, and nurturance. We may assume that air force officers are, as a group, higher sensation seekers than seminarians. Their higher score on the EPPS N Change Scale would support this assumption. Seven of 19 (37 percent) air force subjects quit the experiment before the 40-hour limit, whereas only three of 14 (21 percent) seminary students quit before this time. Although this frequency difference is not statistically significant, one must consider what it must have meant to Air Force officers to "admit defeat" in this experiment sponsored by Republic Aviation and directly related to space flight.

Schwitzgebel (1962) compared the reactions of small groups of Africans (Zulu) and English-speaking whites to 8-hour PD and 8-hour social isolation situations. All subjects had more than 11 grades of school and most were first- or second-year college students. A few subjects from both groups reported vivid images, sensations, or dreams. The Zulu subjects showed less variation on simple perceptual and cognitive measures and were less accurate in estimating passage of time and slow in locating Embedded Figures. These latter two differences were group differences and not related to the variation in experimental conditions. No data is reported on emotional reactions. The study contributes little to our understanding of cultural differences because the Africans were already somewhat experienced in an urban environment.

SUMMARY

It is difficult to summarize the range of findings related to experimental and subject variables discussed in this chapter. Practically all of the variables have been shown to influence some type of response to SD or PD. Organization of such a complexity of findings can only be done

within the framework of a model or theory, and that is reserved for the final two chapters of this book.

Much of the earlier work on SD examined responses to SD without appropriate controls for the subject's own baseline of response or for the many variations imposed by the SD environment. The term sensory deprivation carried assumptions that these effects were due to the perceptual restriction in the SD situation. There are some unique effects which are enhanced by perceptual restrictions (e.g., reported visual sensations and unreality stress), but more carefully controlled studies have indicated that the subject's set and personality and the social-isolation and confinement aspects of the SD experiment produce many of the classical SD effects. There seems to be more response variation produced by variations in control conditions than variations in SD or PD conditions. Many of the earlier conclusions must be reexamined in light of this fact.

4

Hallucinations, Reported Sensations, and Images

Marvin Zuckerman

Of all the phenomena reported in the initial experiments of the McGill group (Bexton, Heron & Scott, 1954, Heron, Doane & Scott, 1956), the hallucinations reported by the perceptually isolated subjects seem to have gripped the interest of clinicians and theorists as well as laymen.[1] There were several reasons for this interest (1) the phenomena were unexpected by both experimenters and subjects, (2) the phenomena were qualitatively distinct and suggested the possibility of a 'miniature psychosis', (3) the results seemed to have relevance for psychoanalytic and neurophysiological theories, and (4) there were many anecdotal accounts of hallucinations under sensory-deprivation like conditions which the experimental approach appeared to confirm Considerable research was directed at these phenomena but lately interest seems to have fallen off The reasons for the diminishing interest in SD hallucinations" seems to be due to the low incidence or absence in some studies, the fact that they can be obtained in very short exposures to isolation, and to the supposed influence of set in their production Another reason is the banishment of the study of imagery from the realm of behaviorism and the stigma attached to this work (Holt, 1964)

Five years ago, Zuckerman and Cohen (1964a) reviewed the area of "sources of reports of visual and auditory sensations in perceptual isolation experiments Many of the questions raised in this article are still unanswered, and some of the tentative conclusions have been challenged Many of these conclusions were based on comparisons of the results in various experiments conducted in different laboratories In retrospect, it appears that it may be misleading to compare experiments which used different methods of defining the response phenomena Consequently, this chapter will concentrate on series of studies conducted within the same laboratories unless two laboratories have used the same response methods

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1 A comprehensive review of other isolation phenomena such as delusions body illusions emotional reactions and somatic complaints has been provided by Schultz (1965) and Zuckerman (1964b)

Table 4–1 lists the frequency results in various experiments with the conditions of the experiments summarized This table is useful in giving an idea of the range of conditions that have been tested and the range of results that have been found It is apparent that the interlaboratory differences are a major source of variance It is also evident that the phenomena of reported visual sensations are typically found in only half of the subjects and that the more structured sensations are generally found in about a fifth of the subjects This poses a problem if one wishes to study this area for fallacious conclusions can be drawn from studies using small numbers of subjects Since the distributions of reported sensations are not normal with the greatest frequencies in the zero category, comparisons of frequencies and proportions must be used instead of parametric statistics Proportions are highly unstable when the denominators are small A case in point is the series of 12 experiments conducted at Princeton which will be reviewed later (Suedfeld & Vernon 1964) The Ns in these experiments ranged from 4 to 11 Because the number of hallucinators defined by their criteria were small they obtained no more than one or two such subjects in most of the groups Such small proportions make it difficult to evaluate the effects of the variations in conditions in these experiments

Definitions

The phenomena in question have been termed 'hallucinations images and reported sensations In the previous review (Zuckerman & Cohen 1964a) little attempt was made to distinguish between these terms because most investigators seemed to use them synonymously At that time we used the Murphy Myers and Smith (1963) phrase reported visual (or auditory) sensations (RVS or RAS) as a generic term for all of the phenomena Because Suedfeld and Vernon (1964) have indicated that the disagreement on definition may lead to disagreements about results it may be time to consider the kinds of criteria which have been used to distinguish the various kinds of phenomena

Definition begins with a reported sensation in the absence of an obvious object of stimulation in the physical environment. In good sensory deprivation (a totally dark soundproof room) conditions there is little problem in distinguishing between real and 'imagined sensations However when blackout masks are used and the soundproofing is inadequate the role of light leaks and building noises in producing reports must be considered When the situation is a perceptual-deprivation one (homogeneous constant stimulation using translucent goggles or dome and white noise or other screening noise) a distinction must be made between illusions and hallucinations Illusions represent the distortion of a real physical object e g a spot which is imagined to be a spider, or the noise in the earphones described as rushing water

TABLE 4-1. Summary of Isolation Groups

Experimenters	Groups	Visual[1] Cond.	Aud[2] Cond	Max. Hours Isol.	Set	Verbal During	Sex Ss	N	Response[3] Methods	RVS% A	RVS% B	RAS% A	RAS% B
Chair confinement groups													
Culver[4]		D	SD	2	none	no	M	24	PI	17	0	0	0
Cohen et al (1959)	I Darkness	D (Goggles)	N	1	you will notice sensations	yes	M & F	4	R, PI	25	0	50	50
	II Diffuse light	DL	N	1	normal	yes	M & F	6	R, PI	50	0	33	33
Goldberger & Holt, (1961 a)	Ganzfeld	SL	none	7	none	yes	M	16	R, PI	50	13	?	?
Water tank confinement groups													
Bliss & Clark (1962)		D (Dome)	SD	6	Ss read the literature and reports	no	M	20	PI, Q	30	35	10	25
Shurley (1962 b)		D (Mask)	SD	7	will ask later about feelings and thoughts	yes	M & F	59	R, PI, PQ	25	37	7	10
Respirator confinement groups													
Solomon & Mendelson (1962)	I Observer present	SL	N	36	none	yes	M	17	R, PI	?	18	?	?
	II Severe isolation	SL	N	31	none	yes	M	11	R, PI	?	27	?	?

Table 4-1, continued

Experimenters	Groups	Visual[1] Cond.	Aud.[2] Cond.	Max. Hours Isol.	Set	Verbal. During	Sex Ss	N	Response[3] Methods	RVS% A	RVS% B	RAS% A	RAS% B
Davis et al. (1960)	Visual stimulation	SL	N	7	none	yes	M	10	R, PI	30	20	10	0
Davis et al. (1961)	I Social-strangers	SL	N	11	none	yes	M	10	R, PI	30	30	10	20
	II Social-married	SL	N	11	none	yes	M & F	22	R, PI	0	5	0	0
Zuckerman et al. (1962)		D	N	7	report anything seen normal	yes	F	24	R, PI	67	42	63	33
Bed confinement groups													
Arnhoff et al. (1962)	Learning exp.	DL	N	18	told hallucinations sometime occur	yes-if desired	M	18	R, PI	10	0	0	0
Bexton et al. (1954)		DL	N	48	report images	yes	M	14	R, PI	100	50	?	14
Courtney et al. (1961)	I Large body movement	DL	N	4	report images	yes	M	9	R, PI	?	56	?	?
	II Finger movement	DL	N	4	report images	yes	M	9	R, PI	?	56	?	?
Doane (1955)		DL	N	120	report images	yes	M	13	R, PI	62	31	?	?
Freedman et al. (1961)	I Darkness	D	N	8	report sensations	yes	M	10	R, PI	40	10	50	20
	II Diffuse light	DL	N	8	report sensations	yes	M & F	10	R, PI	40	30	30	10

Table 4 1, continued

Experimenters	Groups	Visual[1] Cond	Aud[2] Cond	Max Hours Isol	Set	Verbal During	Sex Ss	N	Response[3] Methods	RVS% A	RVS% B	RAS% A	RAS% B
Goldberger & Holt (1958, 1961 b)	I Students	DL	N	8	report thoughts and feelings, experience	yes	M	14	R, PI, PQ	36	57	43	21
	II Actors	DL	N	8		yes	M	16	R, PI, PQ	100	50	50	13
Jackson & Kelly (1962)	Extended set & placebo sugges tion	DL	N	1	previous Ss had images — sign of sensitivity, intelligence	yes	M	14	R, PI, PQ	86	43	100	29
Murphy et al (1963)	I Cubicle	D	SD	73	describe visual sensations	yes	M	35	R	67	26	?	?
	II Control					yes	M	37	R	(both groups combined, no differences between them)			
Pollard et al (1963 a)	I Goggles	DL	N	8	report anything unusual	yes	M & F	10	R	50	10	90	40
	II Dome	SL (Dome)	N	8	report anything unusual	yes	M & F	24	R	58	21	50	8
	III Set alteration	DL	N	3	previous Ss report images — sign of intelligence	yes	M & F	11	R	100	55	91	45
Pollard et al (1963 b)	I Placebo	DL	N	8	report unusual experiences	yes	M & F	20	R	50	20	40	20
	II Set plus placebo	DL	N	8	sensations normal	yes	M & F	20	R	45	20	55	25

Table 4-1, continued

Experimenters	Groups	Visual[1] Cond	Aud[2] Cond	Max Hours Isol	Set	Verbal During	Sex Ss	N	Response[3] Methods	R1 S% A	R1 S% B	R4 S% A	R4 S% B
Zubek et al (1963)	EEG study	DL	N	336	report unusual experiences	not encouraged	M	3	PI, PQ	67	0	100	0
Zuckerman & Cohen (1964 b)	I Control	DL	SD	1	report sensations	yes	M	15	R	27	10	100	13
	II Set	DL	SD	1	hallucinations normal	yes	M	15	R	27	33	87	0
	III Set plus placebo	DL	SD	1	hallucinations normal	yes	M	15	R	33	33	100	20
	IV Extended set plus placebo	DL	SD	1	hallucinations normal and sign of intelligence	yes	M	13	R	60	23	93	15
Zuckerman & Hopkins (1966)	Sensory deprivation and EEG	D	SD	1	report unusual sensations and feelings	yes	F	22	R, PI	45	28	36	9
Zuckerman (unpublished)		D	SD	6	none	no	M	20	PI	68	13	90	17
Zuckerman, Levine & Biase (1964) and	GSR I Total isolation	D	SD	3	report sensations only	not encouraged	M & F	21	PI	71	8	50	33
Biase & Zuckerman (1967)	II Sound stim	D	music	3	report sensations only	not encouraged	M & F	24	PI	54	17	25	8
	III Light stim	normal	SD	3	report sensations	not encouraged	M & F	21	PI	25	8	62	25

Further distinctions may be made between waking hallucinations hypnagogic hallucinations dreams fantasies daydreams and images These distinctions are even harder to make on the basis of the subject s reports The distinction between the first three depends upon the subject s degree of wakefulness at the time the phenomena occurred Hallucinations occur during waking states hypnagogic hallucinations during drowsy states and dreams during stage I sleep The only reliable method of determining the arousal level of the individual is by taking EEG recordings Because individuals usually do not report the sensations while asleep it is difficult to determine the point in time where the actual sensation occurred The subject may be reporting a sensation he just experienced or is still experiencing or he may be reporting a hypnagogic hallucination or dream from an earlier period of lower arousal (Rossi Fuhrman & Solomon 1964) This problem will be discussed later in this chapter It is raised now to illustrate the difficulty in defining the phenomena in question

The distinctions between hallucinations and fantasies, daydreams, or images rest on the distinctions made by the subject on the quality of the phenomena and his reactions to them Leiderman (1962) contrasted his subject s questionnaire descriptions of the reported sensations in perceptual isolation with descriptions of nightdreams and daydreams The visual sensations called images by Leiderman were characterized by the subjects as having pleasant affect being under their control to some extent being located in space in front of them being familiar and as having some subject participation These sensations typically changed somewhat were colored and three-dimensional realistic and frequently spontaneous Most of these characteristics were also common to daydreams and nightdreams The visual sensations differed from nightdreams in that they were more familiar and had less subject participation They differed from daydreams in that they were less pleasant and less multicolored

Mendelson et al (1964) correlated attributes of daydreams nightdreams and images expected and reported during a perceptual isolation and a control session without perceptual restriction The attributes of daydreaming and nightdreaming were significantly correlated ($r = 40$) and attributes of images in experimental and control sessions were significantly correlated ($r = 52$) The attributes of images in experimental and control sessions were not significantly correlated with nightdream daydream or expected image attributes

The auditory sensations were similar in quality to the visual sensations in the Leiderman (1962) experiment They were similar to the daydreams and nightdreams in many respects but differed in that they were more familiar than the auditory images in nightdreams and seemed further away and more outside the head than the auditory imagery in daydreams In general nightdreams are distinguished from sensations by their strangeness and the greater involvement of the subject in them while

daydreams are distinguished by their localization inside the subject's head.

In practice, these distinctions are hard to make and must depend upon the way the subject verbalizes his reactions. The distinctions rest on rather fine introspective criteria and the average subject is no Titchnerian-trained introspectionist. Leiderman's (1962) questionnaire offers a method for making these evaluations in a more systematic and objective fashion than relying on free verbal reports.

Murphy, Myers, and Smith (1963) provide explicit instructions of the scoring of RVSs from transcripts of the verbal report. To qualify as an RVS, the verbal report had to contain the verb "see" or a synonym of "see" such as "look" or "seem." Verbs such as "imagine," "visualize," or "think" disqualified the report as an RVS. The verb "see" or its synonym usually had to be in the present tense and was usually qualified if given in the form of a conditional phrase or given in a manner which suggested doubt or qualified possibility; e.g., "I could see flashing lights."

Suedfeld and Vernon (1964) have adapted Guiraud's (1937) criteria to distinguish between RVSs and visual hallucinations. To qualify as an hallucination, an RVS had to have (1) uncontrollability of onset, content, and termination; (2) "out-thereness"; (3) scanability; and (4) apparent reality. Before confinement, the subjects in the Princeton experiments were taught how to describe the visual sensations so that these criteria could be applied to their reports.

Classifications

A number of classificatory systems have been proposed which categorize the RVSs and RASs by the structuredness and meaningfulness of their content. Vernon, McGill, and Schiffman (1958) used a threefold classification: Type I—flashes of light or light experiences lacking shape; Type II—definite shape but geometric in nature, e.g., squares, circles, and latticework; and Type III—integrated and/or animated scenes, e.g., the now-famous "a procession of squirrels with sacks over their shoulders marching purposefully" across the visual field (Bexton, Heron, & Scott, 1954). Murphy used a fourfold classification: (1) vague, diffuse light; (2) geometric shapes and forms; (3) single objects; and (4) complex objects or scenes. Zuckerman, Albright, Marks, and Miller (1962) used a fivefold classification: (1) unstructured and uninterpreted, e.g., spots and light; (2) unstructured but interpreted, e.g., fire and clouds of smoke; (3) geometric forms; (4) meaningful objects, e.g., spectacles and book; and (5) animate objects, animal or human. As in the previous review (Zuckerman & Cohen, 1964a), the RVSs will be grouped into two general categories: (A) including Vernon's Type I and Type II, Murphy's 1 and 2, and Zuckerman's 1, 2, and 3; and (B) including Vernon's Type III, Murphy's 3 and 4, and Zuckerman's 4 and 5. A similar categorization of auditory

sensations groups them into A including all kinds of interpretations of noise and B restricted to the sounds of human voices human presence or music

The criteria which have been proposed by Suedfeld and Vernon to distinguish hallucinations from other RVSs would cut across these categories A subject may scan believe in and not be able to control an A RVS or conversely he may be able to control or may not believe in the reality of a B RVS Because it is impossible to reevaluate the reports of most of the studies with the introspective criteria the author of this chapter is compelled to stay with the content criteria It is hoped that future investigators will gather their data in a manner which will allow more precise analysis of the RVS and RAS phenomena

THE MCGILL STUDIES

The conditions in the experiments of the McGill group consisted of bed confinement for 2 days in a semisoundproof cubicle Subjects wore translucent goggles (which admitted diffuse light and prevented pattern vision) and cotton gloves and cardboard cuffs to prevent tactual stimulation The hum of a fan was used as a masking noise Subjects were led out blindfolded for meals and toilet needs

Hallucinations were uninvited apparitions in the perceptual isolation room of Bexton Heron and Scott (1954) Among our early subjects there were several references rather puzzling at first to what one of them called having a dream while awake Then one of us while serving as a subject observed the phenomenon and realized its peculiarity and extent (p 73) The last 14 subjects were asked about their experiences All of the subjects reported some visual sensations Half of the subjects reported B type sensations e g a row of little men a German helmet Three subjects reported animated integrated scenes of a cartoonlike character

The subjects were surprised by these phenomena This is an important point because it bears on the set hypothesis which attempts to explain these phenomena as being due to expectation or experimental suggestion Neither experimenters nor subjects in this first experiment expected the phenomena which appeared The percentages of Type A and Type B RVS subjects exceed those found in most of the subsequent experiments when more publicity was given to the phenomena

The subjects were interested and amused at first by the sensations but later some subjects found them irritating and complained that their vividness interfered with sleep There was some control by the subjects in that they could see objects suggested by the experimenter but not always as intended or in the form suggested The imagery usually disappeared

during complex mental activity, such as multiplication, but did not disappear during physical exercise or conversation Hallucinations in other modalities were reported including the sound of speaking or music, and kinesthetic and somesthetic phenomena

Heron, Doane, and Scott (1956) decided to expose themselves to perceptual isolation in order to observe the perceptual changes All three observers reported hallucinatory activity after the first day At first the RVSs were simple in form but later became more complex including scenery, people, bizarre architecture, or entire scenes Scanning the drifting scenes caused eyestrain and nausea in the experimenters

Doane (1955) studied the reports of 13 more subjects Two thirds of his group reported Type A sensations and only about one third reported the more complex Type B

The results of the total group and some specific experiments are reported by Heron (1961) Some form of 'hallucinatory activity' was reported by 25 of the 27 subjects The sensations typically progressed from simple to complex The images could be scanned and there was poor control over them They were often quite vivid and could not be terminated at will Only three of the subjects believed that the phenomena were 'real' and produced by outside sources There was considerable movement in the RVSs The onset of the sensations varied from 20 minutes to about 70 hours Some subjects did not report them until they became very compelling and four subjects did not report them until the experiment was completed

The roles of the diffuse light and the effects of movement were tested in small side experiments Opaque goggles were put on three subjects who had been hallucinating persistently In the darkness hallucinatory activity at first appeared more vivid, but within 2 hours had disappeared in two subjects and diminished in the third subject When the translucent goggles were put on again the hallucinations reappeared Two other subjects were run from the beginning with opaque goggles One developed hallucinations while the other did not When translucent goggles were put on toward the end of the experiment, both subjects reported hallucinations The authors felt that the constant diffuse light stimulation was essential for producing hallucinations As we will see, the later literature does not support this hypothesis

Doane (1955) put goggles on four subjects without restricting their motility or audition Two of these four subjects had RVSs and one of them reported an RVS while being taken for a walk In his regular isolation group Doane found that subjects reported increases in RVSs during periods of activity or discomfort These reports by Doane are in flat contradiction to a later hypothesis (Freedman, Grunebaum & Greenblatt, 1961) that restriction of movement enhances hallucinatory activity

The McGill studies of perceptual isolation stopped at this point and were taken up again in Manitoba by Zubek whose studies will be discussed in a later section The scene now shifts to the laboratory of Vernon in Princeton where further attempts were made to find the environmental conditions controlling the RVSs

THE PRINCETON STUDIES

A series of 12 experiments were conducted by Vernon McGill and Schiffman (1958) Vernon Marton and Peterson (1961) and Suedfeld and Vernon (1964) The conditions and results of these experiments are listed in Table 4–2 The durations of isolation ranged from 1 to 4 days The distinctions made between visual hallucinations and visual sensations were described in the Definitions section of this chapter

The first study used four subjects isolated for 48 hours under relatively mild conditions of isolation The perceptual restrictions were relaxed for eating and testing periods No hallucinations were reported In the second study food was stocked in the isolation cubicle and the subject ate in darkness The subjects wore a blindfold when they were taken out to the toilet Subsequently it was discovered that there were light leaks in the blindfold Six of the nine subjects who completed this experiment reported hallucinations All of these RVSs were of Type A according to our classification although they met the authors criteria for classification as hallucinations In the third study the duration of isolation was extended to 4 days and all of the toilet needs and feeding were taken care of within the cubicle so that there was no extra curricular visual stimulation and there was more restriction of activity Only one subject reported a hallucination and this was a doubtful one

The reports in these first three studies were made post isolation in contrast to the McGill studies which used immediate reports made during isolation (Suedfeld personal communication 1963) Subsequently the authors began to use concurrent reporting At this point in their studies the researchers hypothesized that the high frequency of hallucinations in experiment two were due to the inadvertent visual stimulation via the light leaks in the blindfold

In the fourth experiment constant diffuse-light stimulation was maintained using an illuminated panel attached to a welder s face mask which the subject wore at all times In regard to this and other attempts to maintain a constant diffuse visual field it should be noted that a subject may interrupt such stimulation by the simple expedient of closing his eyes Such a maneuver could conceivably create afterimages and other idioretinal phenomena based on a change in stimulation In this study the

TABLE 4 2 Results of Princeton Studies

Experimental Conditions						*Results*	
No of Study	Duration	Visual Stimulation	Motility	Other	No of Subjects	Visual Hallucinations[1]	RVS[1]
1	48 hrs	Intermittent	Extensive		4	0	
2	72 hrs	Intermittent light leaks	Extensive		9	6	
3	96 hrs	None	Moderate		9	1	
4	48 hrs	Constant diffuse	Moderate		10	2	
5	48 hrs	Constant diffuse	Moderate	Thermal noise	11	0	
6	48 hrs	Amorphous	Moderate		10	1	7
7	48 hrs	Geometric figure	Moderate		5	1?	4
8	48 hrs	Rorschach	Moderate		5	1?	3
9	24 hrs	None	Restricted		7	0	
10	24 hrs	None	Restricted	Anxiety	8	1	
11	24 hrs	Rorschach	Restricted	Expectation encouragement	7	0	7
12	48 hrs	Intermittent light leaks	Extensive		4	0	2

[1]Number of subjects reporting

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authors thoroughly informed subjects about the possibility of hallucinations and attempted to assure them that there were no stigma attached to response than in the second experiment this was the first Princeton experiment in which the more structured Type B sensations appeared Both hallucinatory subjects reported this type e g an archway a chapel a cogwheel turning slowly or a river with floating white balls Did the B-type sensations occur in the first three studies? It is likely that they did but the failure to obtain reports until the end of the experiment and the failure to remove the stigma which might make subjects hesitate to remember or report such phenomena may account for the failure to find Type B RVSs

The fifth study added constant sound stimulation thermal noise to the conditions of the prior study No hallucinations were reported by such phenomena Two of ten subjects in this experiment reported hallucinations Although the frequency results of this study indicated less the 11 subjects in this study

In the sixth study intermittent amorphous stimulation was introduced by flashing the stimulus at various intervals on a panel on the wall at the foot of the subject s bed One subject of the ten in this group reported hallucinations He was one of the prolific hallucinators found in some experiments and reported 41 hallucinations more than one quarter of which were the B type Seven of the ten subjects in this experiment reported visual sensations which did not meet the investigators criteria for hallucination Studies seven and eight used other types of stimulation including small diverse geometrical figures and Rorschach cards Only two of the ten subjects in these experiments reported RVSs which might qualify as hallucinations although most subjects reported RVSs It would be illuminating to know which criterion the RVSs failed to meet The large number of RVSs could have been produced as afterimage reactions to the intermittent visual stimulation

The ninth and tenth studies attempted to control the motility factor by providing feeding and toilet arrangement in such a way that the subject did not have to get up from the bed In the tenth experiment an attempt was made to introduce anxiety by suggesting a connection between the experimental conditions and brainwashing neurosis and loss of contact with the world Of the fifteen subjects in these experiments with more severely restricted motility only one reported a hallucination and none reported RVSs

Experiment eleven utilized the same restricted motility of experiments nine and ten the intermittent inkblot stimulation of experiment eight and added a strong positive set for reporting visual imagery The experiment was preceded by a Ganzfeld experience in which subjects were encouraged to report imagery The net effect of these procedures was that all subjects reported RVSs but none reported an RVS which could qualify as a hallucination As will be seen later the findings of Zuckerman and Cohen (1964b) indicate that set has its greatest influence on the least structured RVSs

The final experiment in this series was a replication of the second study which had yielded the most impressive results in the hallucination category The only difference was that the duration of the experiment was reduced from 72 hours to 48 hours This time no hallucinations were reported although two of the four subjects gave RVSs

This series of studies is impressive in the number of conditions varied but unfortunately the findings are inconclusive One reason is the inadequate number of subjects in the various conditions Hallucinations

are rare phenomena and apparently not under strong environmental control. Intermittent stimulation and set appear to produce many RVSs but few hallucinations, using these authors' criteria for the latter phenomena.

THE BOSTON STUDIES

The studies at the Boston City Hospital, conducted by Solomon and others, illustrated how hypotheses evolved from clinical observations may influence experimental work. The original interest of the group in perceptual deprivation developed from observations of psychotic-like symptoms in poliomyelitis patients confined in tank-type respirators in conditions which were perceptually sterile (Mendelson & Foley, 1956).

The experimenters (Wexler, Mendelson, Leiderman, & Solomon, 1958; and Solomon & Mendelson, 1962) set up an experimental situation much like the conditions of the poliomyelitis patients. Normal subjects were confined in a tank-type respirator surrounded by a screen in experiments ranging from maximum durations of 7 to 36 hours. Many subjects quit before the maximum duration, but the data from all subjects are considered together. The artificial light was minimal and constant, but the subject could see a limited field consisting of respirator, ceiling, and screen. The motor was left running as a screening noise, but the respirator was inoperative and the vents were open. In one group of subjects (I), the subject was fed at irregular intervals and provided with urinals on demand. An observer was present but out of view. In the second group (II), the conditions were made more severe by the use of a self-feeding device and the automatic recording of verbalizations. Urine collection still provided some "social" contact for the subject (Solomon & Mendelson, 1962). The authors' categorizations of phenomena reported by subjects during the experiment distinguishes between analogies, daydreams, fantasies, pseudosomatic delusions, illusions, and hallucinations. A hallucination was defined simply as "a sensory experience without basis in reality." Hallucinations so defined, were reported by three of the seventeen subjects in Group I and four of eleven subjects in Group II. Using our criteria, 18 percent of the subjects in Group I gave type B RVSs, while 27 percent in Group II reported this type of RVS. These proportions are fewer than those found in the McGill studies but more than those found in the Princeton studies. Apparently the added restrictions in the second group did not have any significant effect on the frequency of hallucinations. The authors compared hallucinators and nonhallucinators on a number of other responses and preexperimental measures. The hallucinator group did not differ from the nonhallucinator group on: (1) motivation for volunteering, (2) personality characteristics measured by the MMPI and EPPS, (3) length of stay, (4) amount of motor activity, (5) amount of

verbalization (6) duration of sleep (7) somatic complaints (8) errors in time estimates at end of experiment and (9) reasons given for leaving the experiment Results of suggestive significance included (1) in group II the non H group had a larger output in noradrenalin excretion and a larger increase in urine volume output than the H-group and (2) the H group had fewer daydreams and more illusions and pseudosomatic delusions than the non H group

Davis McCourt and Solomon (1960) investigated the role of sensory stimulation They hypothesized that it is not the absence of sensory stimulation but the absence of meaningful stimulation which produces the effects of sensory deprivation Ten subjects were exposed to the respirator perceptual isolation A white light flashed on a random schedule and colored Rorschach cards were also flashed on the wall periodically Three of the ten subjects in this experiment reported hallucinations but only two or 20 percent reported B type RVSs The percentage is similar to those found in the prior two experiments reported by this group and indicates neither a facilitating or inhibiting effect of intermittent stimulation on the more complex hallucinatory response These results are like those of Suedfeld and Vernon (1964) who used similar intermittent stimulation

An attempt was made to assess the role of social isolation in producing the effects reported in these experiments Davis McCourt Courtney and Solomon (1961) ran two studies using two types of social contact In the first group five pairs of male subjects strangers to each other were placed in adjoining respirators In the second group 11 pairs of college students and their wives were placed in twin respirators In the first group three of the ten or 30 percent of the subjects reported Type B RVSs in the second experiment only one of 22 subjects or 5 percent reported Type B RVSs Social type stimulation *per se* did not reduce Type B RVSs but the presence of one s spouse did seem to have an inhibitory effect on these phenomena It should be noted that the married couples talked more than the male strangers and their talk was more intimate Thus the social and sensory isolation of the married couples was quantitatively less than that of the male strangers

Finally an attempt was made to assess the role of physical inactivity in producing the phenomena of perceptual isolation (Courtney Davis & Solomon 1961) The respirator method of confinement was not used in this study Subjects were confined on a bed for 4 hours in a cubicle wearing eyecups which permitted only perception of a diffuse field of light White noise was used to provide a uniform auditory stimulus Nine subjects were required to make a large body movement upon receipt of a tactual signal while nine other subjects were only required to make a small finger movement on receipt of the same signal Five subjects or 56 percent in each of these groups reported Type B RVSs It would seem

that the relative amount of physical activity did not affect the incidence of RVSs The actual proportions of subjects in these groups reporting Type B RVSs was higher than in the previous respirator experiments despite the fact that these experiments were limited to 4 hours duration while the other experiments were allowed to run 10½ or 36 hours if the subjects stayed that long One reason for the high rate of Type B RVSs may have been the more complete restriction of the homogeneous visual field in the movement experiment

THE HumRRO GROUP

The studies of the Human Resources Research Office (HumRRO) group (Murphy Myers & Smith 1963) represent some of the best work in this area Their work is characterized by the use of control groups adequate Ns and careful attention to the development of reliable response measures The subjects for these studies were soldiers from Fort Ord California The use of soldiers gave the experimenters the advantage of a large homogeneous population and a well-controlled environment, even for control groups The durations of these experiments were generally 4 days

The pilot experiment (Murphy & Myers 1962) consisted of a study of the effect of prior verbalization and an implicit set to see things and the effect of explicit positive and negative sets on RVSs during the last 15 minutes of a 25-minute sensory deprivation period The prior verbalization and implicit set were induced by giving half of the subjects three cards of the Rorschach test prior to the experiment Half of the subjects were told that visual sensations in the dark were normal and experienced by all people (positive set) while the other half were told that these sensations were only reported by psychiatric patients (negative set) RVSs were scored for frequency and for complexity the latter score derived from a Guttman scaling technique This technique was applicable to RVSs because it was found that subjects who reported complex RVSs usually reported less complex RVSs A description of Murphy and Myers classification of RVS phenomena and their criteria for scoring an RVS from the language in the report were described in the Definitions section of this chapter

Prior verbalization did not affect the frequency or complexity of RVSs but the explicit sets given by the experimenters did affect these phenomena Negative set resulted in fewer and less complex RVSs in that group

Apart from the strong effects of the sets there are two somewhat startling results of this experiment One is that despite the fact that a subject practically branded himself as abnormal by giving RVSs many in

the negative set group did give such reports (the average per subject was 7 7 RVSs) The second point is that so many reports of RVSs were made in both groups in a short 25 minute sensory deprivation period Murphy and Myers concluded The results of this study do not rule out the possibility of an increase in frequency of visual sensations under prolonged isolation however they do suggest caution in making inferences about the occurrence of visual experiences in sustained isolation studies unless adequate measurement procedures are utilized and data from control groups obtained (1962 p 58)

The HumRRO group then began a series of studies in 1960 in which the carefully developed during isolation report technique utilizing the Guttman scale of complexity was used together with a similar scale applied to the relevant items of a postisolation questionnaire These two measures proved to be significantly related (r = 77 for cubicle and 90 for control groups)

Subjects assigned to the sensory deprivation condition were isolated for a period of 96 hours in dark soundproof cubicles Control subjects spent their time in the barracks or performing minor duties around the post In the first runs 55 cubicle and 37 control subjects were used After 48 hours they were given the during isolation RVS test (D RVS) which consisted of a request to describe visual imagery during a 30 minute period while lying in the darkness The postisolation RVS test (P RVS) was contained in a general questionnaire given after the 96 hour period The control subjects took the D RVS test in the same cubicles as the experimental subjects but entered the room just for the test and came out immediately after termination of the test An additional 11 cubicle and 11 control subjects took the D RVS test after 72 hours of isolation for the cubicle subjects Army General Classification Test scores were available for all subjects and comparisons were made of subjects high and low on this test of intelligence Since all subjects were chosen from those above average on this test these comparisons were of bright and superior subjects The second series of runs used 67 cubicle subjects and 66 controls In this series only the P RVS test was used there was no formalized reporting during isolation

The results for the D RVS tests indicated no differences between cubicle and control or between higher and lower intelligence subjects on the complexity of verbally reported RVSs The results for the P RVS test are given in Table 4-3 The cubicle vs control difference was significant on the postisolation test where cubicle subjects reported more complex RVSs than control subjects The difference between the groups who had been asked to watch for images during a 30 minute period in the 48th hour of the study and the groups who made no reports during isolation was also significant Apparently the intervening D RVS test influenced the complexity of reports on the P RVS test In the control group who had

TABLE 4-3 Mean Postisolation RVS Complexity Scores and N for Cubicle and Control Groups

		Cubicle	Control
I	Postisolation Test Only	1 79	0 24
	N	67	66
II	Postisolation Test, Preceded by During Isolation Test	2 46	1 43
	N	35	73

F Cubicle vs Control = 59 76 df 1/201, $p < 001$
F I vs. II = 31.06 df 1/201, $p < 001$

SOURCE Reprinted by permission from D B Murphy, T I. Myers, & S Smith, U.S Army Leadership Human Research Unit, Hum RRO Res Rept., November 1963

taken a D RVS test the mean complexity score was barely above zero indicating little RVS activity in their barracks environment There was a significant difference between low and high intelligent subjects on the P RVS measure the less intelligent reported more complex RVSs

Further experiments established the fact that the length of time spent in sensory deprivation prior to the 30 minute test period (48, 72, or 96 hours) did not affect the complexity score of the D RVS test

In order to test whether the time spent in the dark was a significant influence on the P RVS test apart from the set factor, a group of 72 naive subjects spent 30 minutes in the dark cubicle and then filled out the questionnaire containing the P RVS items This group had no information about the isolation studies in contrast to the prior control group Once again the cubicle group was significantly higher on the P RVS test The authors conclude the important aspect of isolation was that it provided the cubicle Ss with lengthy waking periods in the dark during which time more frequent and more complex RVSs occurred than was the case for control Ss whose waking hours took place more often in a lighted everyday world (p 48) This explanation ignores the difference between the groups who had a prior RVS test and those who had none Furthermore it would not explain why other studies which confined subjects in the dark for long periods rarely obtained postisolation reports of RVSs

Some other results of these studies are worth commenting on

1 There was no significant difference between P RVS scores of cubicle subjects who requested release prior to 48 hours and those who stayed for the full 96 hours

2 Nonvolunteering soldiers were put in with the controls There were no differences between controls who had volunteered for isolation and those who had not on the D RVS or the P RVS tests

3 Naive subjects exposed to 30 minutes of isolation scored no higher on the P RVS test than controls who had been informed about the experiment Another group of naive subjects who took the D RVS test had significantly higher D RVS scores than the control group

4 A group of naive subjects took the D RVS test and then predicted how they thought a man would fill out the questionnaire containing the P RVS items after four days of isolation This group expected that the isolation group would give the same number of RVSs as normally without the long isolation period Since the actual isolation group reported more RVSs they were mistaken They also could not predict the particular pattern of increases in the four categories of RVSs

5 Since ability to verbalize might have affected the RVS scores a separate experiment using a nonverbal method of reporting RVSs was conducted Subjects were instructed to answer questions about RVSs at the end of a 30 minute period by pulling a lever There was no significant difference between 26 cubicle and 32 control subjects on this measure

6 To test for the effects of dark adaptation and drowsiness a separate study was run employing three groups an immediate report group who took the D RVS test shortly after entering the cubicle a delayed group who did not report until after a 30 minute wait in the dark and a wake up group where the terminal end of the 30-minute wait was occupied with mental arithmetic problems

More complex RVSs were reported by the immediate and the wake up groups than by the delayed group but there was no difference between immediate and wake up conditions These results were interpreted as indicating that dark adaptation evidently did not affect the level of D RVS score il steps were taken to arouse the Ss from drowsiness associated with the time required for adaptation to occur (p 63)

The results of these studies point to a state of wakefulness or arousal but not necessarily a state of very high arousal (as in the quitters) as being optimal for RVS reports The subjects prior information expectancies or ability to verbalize do not seem to be important factors in producing the obtained RVSs

COMPARISONS WITH OTHER STUDIES USING THE HumRRO QUESTIONNAIRE

The questionnaire devised by the HumRRO group has been used in studies of varying durations at Princeton Manitoba and my own laboratory The mean scores of the total RVS scale of sensory deprived and control groups in two 8 hour two 24 hour one 96 hour and two 168 hour experiments are listed in Table 4–4 The type of control groups used in these experiments differed in that the HumRRO and Princeton studies

TABLE 4-4 Mean RVS Scores from Postisolation Questionnaire

Study[1]	*Hours*	*SD or PD Social Isol & Confinement*	*Social Isol & Confinement*	*Confinement*	*Ambulatory*
A	8	2 06	1 53		
B	8	5 54[2]	2 67	2 04	40
C	24	3 75[2]	1 42		
D	24	5 15[2]			31
F	96	6 87[2]			1 69
F	168	6 61[2]		2 39	1 22
G	168			3 64	1 00

[1](A) Zuckerman et al., 1966 (B) Zuckerman, Persky, Link, & Basu, 1968a (C) Persky et al., 1966, (D) Suedfeld, personal communication (E) Murphy et al., 1963 (F) Zubek & MacNeill, 1967 (G) Zubek & MacNeill, 1966

[2]Significantly higher than nearest control condition

used only ambulatory controls who were unconfined and exposed to normal life environmental stimulation Our own studies used subjects as their own controls (A and C) or different types of independent control groups including social isolation and confinement controls (B) During the control sessions, confinement groups were restricted on a bed in the same soundproof room used in the isolation session, but were given some mild stimulation (pictures and music in the 8-hour group, radio and television in the 24 hour group) The studies using ambulatory controls all obtained significant differences between sensory deprived and control groups Studies B C and F, which used confined controls also obtained higher RVS scores in sensory deprivation than in a confinement, with or without social isolation Only one study, A, failed to obtain this difference In this study blackout goggles were used instead of a dark room There was no systematic tendency for RVS scores of experimental groups to increase between 8 and 24 hours and considerable variation between experiments is found in these groups There was an increase in RVS scores going from the 1-day to the 4-day and 1 week studies There was little evidence of RVS phenomena in ambulatory groups studied for an 8 to 24 hour period, but some increases occur in the four-day to one week experiments Confinement groups do not show much increase over the range studied The reduction of patterned visual stimulation facilitates post isolation reports of visual sensation but in any environment P RVS reports are not absolutely zero perhaps because control subjects do spend some time in conditions of reduced sensory input (e g prior to falling asleep) There appears

to be no systematic increases in postisolation RVSs between 8 and 24 hours although increases are seen after four days of deprivation Of course these conclusions do not apply to during isolation reports which show no relationship or even decrease with duration of the experiment (Zuckerman et al 1962)

THE MANITOBA STUDIES

Zubek and his colleagues have reported a series of experiments characterized by long periods of isolation (1 to 2 weeks) and variations of conditions in different experimental groups Several groups were run studying the effects of variations in confinement without perceptual restriction (Zubek et al 1963 1966)

Sixteen subjects were tested during and after sensory deprivation conditions lasting 1 week (Zubek Pushkar Sansom & Gowing 1961) In this group 56 percent reported Type A RVSs while only 13 percent reported Type B RVSs In another experiment using perceptual deprivation (constant diffuse light and noise) for one week only 15 percent reported Type A RVSs and none of the subjects reported Type B RVSs Although these experiments were of durations considerably longer than prior experiments they are notable for their low incidence of RVSs particularly of the more complex type In another 1 week perceptual isolation experiment (Zubek 1964b) in which the severity of the isolation was increased by allowing no intrusions and requiring the subject to wear heavy leather gloves only two of 16 subjects (13 percent) gave RVSs and these were of the simpler (A) type In one of the longest perceptual isolation experiments reported lasting 2 weeks Zubek (1964a) found almost no RVS phenomena and the few that were reported were of the simplest variety

One thing stands out about the conditions of these experiments concurrent report of RVSs was not encouraged The subjects had to wait until the infrequent test periods or the end of the experiments to report the RVS phenomena In view of the finding of Murphy Myers and Smith (1963) that postisolation measures not preceded by during isolation reporting elicited less complex and probably fewer RVSs it may be that the lack of reporting during Zubek s experiments accounted for the low frequency of RVSs in his retrospective reports

In the experiments comparing severe immobilization recumbent controls and ambulatory (life) controls Zubek et al (1963) found five subjects giving hallucinatory phenomena three were among the 40 subjects in the severely immobilized group and two were in the recumbent control group Although the subjects were stimulated during the days, four of the five hallucinations occurred during the quiet of evening when the lights were turned on low Although absolute sensory restriction is not

necessary for RVS apparently some reduction of stimulation facilitates them

The conclusion drawn from the HumRRO experiments that the duration of isolation is not a very crucial variable is underlined by the paucity of RVSs in Zubek s studies which have used very long durations of perceptual deprivation

SOME OTHER LONG DURATION STUDIES

Other investigators using long durations of isolation have also failed to find any significant number of hallucinators Arnhoff Leon and Brownfield (1962) ran 18 subjects in a 2-day perceptual deprivation situation Six failed to complete the full duration None of the subjects reported hallucinations despite the fact that they were told in advance that such phenomena might occur Kokubun and Ohyama (1965) obtained introspective reports and interviewed 11 subjects after 24 hours of perceptual deprivation They obtained only basic or elemental RVSs and RASs (presumably Type A) but no structured ones Smith and Lewty (1959) used 20 volunteers who stayed in a perceptual deprivation situation for periods ranging from 6 to 92 hours Eighteen of the 20 stayed for 1 day or more Only one subject reported a hallucination and this was a doubtful one Cameron Levy Ban and Rubenstein (1961) kept some subjects (the actual number not reported) in sensory deprivation up to a maximum of 16 days They reported that auditory and visual hallucinations were quite rare All of these studies have used long durations of 1 day or more and failed to find many reports of hallucinations Undoubtedly Type A RVSs must have occurred but either were not asked for by the interviewers or were not reported for other reasons Although the methods are not thoroughly described in many of these reports it would appear that spontaneous reporting of imagery was not encouraged by the experimenters in any of these experiments Most of them apparently relied on postisolation inquiries A spontaneous visual sensation may be remembered more vividly by a subject in isolation for 1 hour than one in for a day or a week

THE MICHIGAN STUDIES

Jackson and Pollard (1962) have questioned the physiological and psychoanalytic theories of sensory deprivation They advocated a theory which states that RVSs are a function of the subject s prior information of expected reactions his motivation to experience RVSs and report them and the use of continuous reporting instructions which have a self suggestive effect

Jackson and Kelly (1962) set subjects for RVSs by giving them an extended talk on the expected effects of a new drug (actually a placebo) which was supposed to produce hallucinations and other changes in sensory deprivation They also added that the ability to see images was a sign of sensitivity and intelligence In only 1 hour of perceptual deprivation 86 percent of their subjects reported Type A RVSs and 43 percent reported Type B RVSs Because the isolation period was only an hour they assumed that the RVSs were produced by the set The lack of a control group in this experiment made their conclusions somewhat premature

In a more carefully controlled experiment Pollard Uhr and Jackson (1963a) compared a group wearing goggles admitting diffuse light a group whose visual field was restricted by a dome admitting diffuse light and a third group wearing goggles The first two groups were exposed to 8 hours of isolation with instructions only to report anything unusual The third group was given only 3 hours of perceptual deprivation but was given a more elaborate positive set e g previous subjects reported images images are a sign of intelligence There was little difference between the 8 hour goggle and dome groups in the incidence of RVS subjects but there was a marked increase in the number of subjects reporting both types of RVSs in the three hour positive set group Over all the conditions 73 percent of the males and 61 percent of the females gave RVSs the difference was not significant

The same group (Pollard Uhr & Jackson 1963b) then ran a more elaborate experiment involving five groups I—placebo no set II—placebo plus set III—tranquilizer no set IV—tranquilizer plus set and V—energizer plus set A look at this study listed in Table 4–1 will reveal that there was no difference between the incidences of subjects giving RVSs in placebo groups with and without set The group given a set for RVSs along with a tranquilizer reported more Type B RVSs than the other groups but in general the results of this study did not confirm the findings on the major influence of positive set in the earlier study

OTHER STUDIES VARYING SETS

The study of Murphy and Myers (1962) was discussed previously These authors demonstrated that a group given a positive set to report RVSs produced a greater number and more complex RVSs than a group given a negative set

Zuckerman and Cohen (1964b) used I—a control group simply told to report sensations II—a group given a mild suggestion that they would have RVSs and that such phenomena were normal III—a group given the mild suggestion plus a drug (placebo) suggestion and IV—a group given

the extended suggestions and drug suggestions used by Jackson and Kelly (1962). The incidence of Type A RVS subjects was significantly increased by the Jackson and Kelly suggestions: 27 percent of the subjects in Group I reported these less complex RVSs, while 60 percent of the subjects in Group IV reported them. Most of this difference was accounted for by Murphy, Myers, and Smith (1963) Type I RVSs (light changes, specks, and spots). The suggestions used did not affect the incidences of any of the more complex RVSs The subject's prior knowledge or expectations before the experimental set was not related to the occurrence of RVSs. Six of 12 Ss expecting to have "hallucinations" gave RVSs and 23 of 46 Ss not expecting hallucinations gave RVSs. The proportions were the same, indicating no effect of expectation on RVSs. The conclusion drawn was that extreme suggestive sets can influence RVS reports, but only those of the least structured type, which might be seen by anyone who attends carefully to his visual field in the absence of external visual stimulation.

Short and Oskamp (1965) also replicated the Jackson and Kelly (1962) study, using a "high suggestion" group comparable to Jackson and Kelly's experimental group and a low suggestion group like Group I in the Zuckerman and Cohen (1964b) study. The same percentage of subjects (42 percent) in each group reported sensations, indicating no effect of suggestion. The percentage reporting sensations was quite close to the percentage (46 percent) reporting any sensation in Zuckerman and Cohen's Group I.

Ziskind (1965) studied the effects of varying instructions on RVSs in normals wearing eyepatches for 10-minute periods. Five groups received instructions involving a declining order of definiteness or direction. Group I was told "describe what you see in your visual fields including changes, and any images should they occur." Group II was told "describe any images you perceive." Group III was instructed "report your thoughts, feelings, images, and perceptions." Group IV was told simply "report what you experience." Group V received no prior instructions. Reports of any type of visual sensation, A or B, declined from Group I to Group V. The occurrence of the complex Type B RVS was as follows: Group I—27 percent, Group II—50 percent, Group III—50 percent, Group IV—38 percent, and Group V—25 percent. As in the Zuckerman and Cohen (1964b) study, the Type A RVS was markedly influenced by the instructions while the type B RVS showed no direct variation with instructions.

Reed (1962) has reported a study comparing ten subjects who expected that 1 hour of sensory deprivation would have profound effects, with ten subjects who believed that the effects would be minimal. The subjects were exposed to 40 to 60 minutes of perceptual deprivation and asked about their experiences in a postexperimental interview. The only RVS phenomena showing a significant difference in incidence in the two

groups were changes in brightness or flickering of light corresponding to Murphy s Type I RVSs The group with greater expectations of effects reported more of these phenomena Admissions of other disturbing effects were more pronounced in the high expectancy group

Leon and Arnhoff (1965) found a greater amount of Imagery Disturbance in subjects who were told that they were expected to experience such phenomena than in a group which was told that these phenomena sometimes occurred and another group which was told nothing

Orne and Scheibe (1964) confined experimental and control groups in a well lighted ordinary room for 4 hours The experimental group was run in a manner which represents a caricature of the usual conditions in sensory deprivation experiments e g white coats panic buttons release forms and instructions to report imagery fantasies and the like The control group was treated more like a control group Seven of the ten experimental and four of the ten controls reported perceptual aberrations (mostly illusious rather than RVSs or hallucinations) The difference in the incidence was not significant

These studies generally support the conclusion that only the least structured type of RVS is affected by expectancy or set but that more structured sensations or images are not markedly influenced by these factors

Rossi Sturrock and Solomon (1963) compared the vividness of imagery reported by subjects after hypnosis placebo suggestion sensory deprivation and normal conditions Although hypnosis enhanced imagery placebo suggestion had no effect and sensory deprivation actually resulted in lower vividness of imagery They conclude that imagery cannot be explained by the hypothesis that suggestion enhances visual imagery in isolation

THE ZUCKERMAN STUDIES

Zuckerman Albright Marks and Miller (1962) studied RVSs given by 24 student nurses during 6 hours of sensory deprivation in a tank type respirator like that used by the Boston group The exact time of occurrence of all RVS phenomena was noted The percentage of subjects giving RVSs in the first hour of sensory deprivation was about 50 but from the first to fourth hour this percentage fell steadily to about 14 percent in the fourth hour and increasing only slightly to 20 percent in the sixth hour Type A RVSs were frequently reported in the first hour dropped precipitously in the second hour and remained low for the remaining 4 hours Type B RVSs dropped off more gradually during the 6 hours of the experiment A score based on the frequency and structuredness of RVSs was

not correlated with any of the stress scores based on spontaneous verbaliza tions but was correlated significantly ($r = 49, p < 05$) with reported au ditory sensations

Zuckerman, Levine, and Biase (1964) and Biase and Zuckerman (1967) conducted experiments in which 36 undergraduate males and 36 undergraduate females were exposed to three hours of confinement with one third of each group in each of the following conditions I—total sen sory deprivation, no light or sound, II—auditory deprivation with visual stimulation, and III—visual deprivation with auditory stimulation Table 4–5 shows the incidence of RVS subjects in these three groups In both groups lying in darkness for three hours, with or without auditory stimu lation, there was a significantly greater number of subjects making RVS reports than in a group confined in the same room with the lights on The same results were found in an 8-hour experiment (Zuckerman, Persky Link, & Basu (1968a) These results support the conclusion that some re duction of external visual stimulation facilitates RVSs, although stimula tion in other sensory modalities does not necessarily inhibit RVSs Similar results were obtained for reported auditory sensations, which were least

TABLE 4 5 Incidence of Reported Sensotions in Three Isolotion Conditions

Type of Sensation	*Conditions*	*No Male Ss Reporting Sensations*	*No Female Ss Reporting Sensations*	*Total*	Ss
Visual A or B Types	No light or sound	19	5	24	
	Light, no sound	8	16	24	$X^2 = 12\ 01$
	Sound no light	17	7	24	$p < 01$
	Total Ss	44	28	72	
Auditory B type	No light or sound	8	16	24	
	Light no sound	6	18	24	$X^2 = 4\ 77$
	Sound no light	2	22	24	N S
	Total Ss	16	56	72	
Somes-thetic	No light or sound	14	10	24	
	Light, no sound	4	20	24	$X^2 - 10\ 50$
	Sound no light	6	18	24	$p < 01$
	Total Ss	24	48	72	

frequent in the group with auditory stimulation although the differences here fell short of significance Kinesthetic or somesthetic reported sensations were significantly more frequent in the total deprivation group than in either of the partial deprivation groups so that these phenomena do appear to be inhibited by the competing stimulation of other modalities

In this study there were no sex differences in the frequency of all types of RVSs However eight males (22 percent) gave Type B RVSs while none of the 36 females reported this complex type of RVS This difference was significant This result was not found in the 8 hour experiment (Zuckerman Persky Link & Basu 1968a)

Examining our experiments reported in Table 4–1 there are several observations which can be made One is that there is no systematic variation in percentages of subjects giving RVSs as a function of SD time (1 to 24 hour duration experiments) Second there is a smaller number of Type B RVSs given in the experiments where subjects were not encouraged or not allowed to make verbal reports during the experiment In five 1 hour groups where these reports were encouraged and in a 6-hour group reported in the respirator-confinement section the percentages reporting complex visual sensations ranged from 18 to 42 percent In seven groups where during isolation spontaneous reporting was discouraged the range was 8 to 17 percent Type A RVSs were still high in most of these latter groups But one group (Zuckerman et al 1966) who wore blacked out goggles instead of simply being confined in a dark room produced few Type A RVS subjects and not much more than the Group III in the Biase and Zuckerman experiment where the lights in the room were on This raises the question of whether opaque goggles restrict RVS tendencies compared with a dark room Subjects wearing translucent goggles can project images on the goggles themselves but opaque goggles may have a tendency to interfere with the out there projection quality of retinal images which are experienced as sensations This could explain the reduction in hallucinatory behavior when Heron (1961) switched from translucent to opaque goggles However Ziskind (1965) is able to elicit a substantial number of Type A RVSs from eye patched subjects

OTHER STUDIES COMPARING THE EFFECTS OF VARIATIONS IN VISUAL AND AUDITORY RESTRICTIONS

Freedman and Greenblatt (1960) tested ten subjects in darkness and ten in diffuse light conditions The proportions of subjects reporting Type A and B RVSs were almost identical in the two groups Four subjects were

run under both of the two conditions two had RVSs in both conditions one in neither condition, and one in the darkness condition only

Cohen, Rosenbaum, Dobie, and Gottlieb (1959) compared four subjects with blacked out goggles and six with diffuse light goggles Type A RVSs were more frequent in the diffuse light group, Type B RVSs were absent in both groups

Leiderman (1962) tested eight male and eight female subjects in two conditions I—homogeneous visual field achieved by subjects wearing halved ping pong balls over the eyes, and II—intermittent visual stimulation with travel slides In the intervals between slides in this condition, the subject faced a white, ground-glass screen All subjects were run in both conditions and the order of the conditions was counterbalanced Each condition lasted 2 hours All subjects in this experiment reported 'images probably because the instructions made no differentiation between images and sensations and the subjects were required to report their images on receipt of a tactile stimulus There were no significant differences in the frequency of images in the visual restriction and visual stimulation conditions, however, auditory and somesthetic images were significantly more frequent in the visual restriction group There were no significant sex differences in reported imagery

Mendelson et al (1964) used 20 deaf adult male college students in another study where each individual was tested for imagery in two conditions perceptual isolation (homogeneous visual stimulation) and control conditions (patterned stimulation) Half of the subjects were congenitally deaf and half had acquired deafness Half of the subjects in each of these groups had the experimental condition first and half had the control condition on the first occasion More visual imagery was reported during the perceptual isolation than during the control session More imagery was experienced during the first session than during the second session for the congenitally deaf subjects but not for the acquired deaf subjects There were no significant main effects for auditory or somesthetic images The same type of interaction between type of deafness and sessions that occurred for visual images also occurred for auditory images

Vosberg, Fraser, and Guehl (1960) also used subjects as their own controls in three successive conditions but during consecutive hours of the same experiment I—darkness and silence II—diffuse light and silence and III—auditory stimulation (white noise) and darkness They found no difference between sound and visual stimulation hours in RVSs or RASs and only slight differences between the sensory deprivation and partial perceptual deprivation conditions

Ruff Levy, and Thaler (1961) put nine subjects in perceptual deprivation (frosted goggles) and 54 subjects in sensory deprivation conditions Type A RVSs and RASs were not uncommon but Type B RVSs

occurred in only two subjects, one in the PD and one in the dark SD condition.

These studies, taken together with the studies of Davis, McCourt, and Solomon (1960), Pollard, Uhr, and Jackson (1963a), and Suedfeld and Vernon (1964) indicate that *there is no difference between the RVS eliciting potentialities of (A) total darkness; (B) diffuse light, or invariant, homogeneous visual stimulation; and (C) intermittent stimulation, in an otherwise monotonous visual environment.* However, an unrestricted patterned perceptual environment is less conducive to RVSs than an invariant one. There is evidence in the Biase and Zuckerman (1967), Leiderman (1962), and Zuckerman, Levine, & Biase (1964) studies that visual restriction is more conducive to kinesthetic or somesthetic phenomena than environments with patterned visual stimulation. Leiderman also reports that RVSs declined over time during the 2-hour experiment which is similar to the findings of Zuckerman, Albright, Marks, and Miller (1962).

THE WATER-TANK STUDIES

The water-tank method of sensory deprivation was pioneered by Lilly (1956), who reported profound effects, including hallucinations, in himself and one other subject. The aim of the water-tank method was to "reduce the absolute intensity of *all* physical stimuli to the lowest possible level." Data on 79 subjects in two experiments have been provided by Bliss and Clark (1962), Cambareri (1959), and Shurley (1962b, and personal communication). In both experiments, lasting up to 7 hours, slightly over one third of the subjects gave Type A, and about the same proportion gave Type B RVSs. Reference to the figures in Table 4–1 will show that these proportions of RVS subjects, while higher than the median, are not exceptionally high compared to the McGill (Bexton, Heron, & Scott, 1954) studies or those of Courtney, Davis, & Solomon (1961). Goldberger and Holt (1958, 1961a, and 1961b), or others which used bed confinement and nonpatterned, constant stimulation. The expectancy that the greater degree of reduction of sensory stimulation (particularly the stimulation stemming from muscle discomforts) would produce greater RVS phenomena has not been borne out.

SOME OTHER INDEPENDENT VARIABLES

Zuckerman and Cohen (1964a) suggested in their review that body position may be more important than amount of physical activity in producing RVSs. Noting the rarity of Type B RVSs in studies confining sub-

jects in chairs instead of beds we speculated that lying on one s back might be more conducive to RVSs than other positions

Another hypothesis suggested in this review and in the 1964 review was that the method of reporting RVSs might be crucial Experiments encouraging continuous reporting usually elicit many RVSs while experiments which require subjects to postpone reports until a test period or a post isolation interview tend to elicit few RVS reports

Both of these hypotheses were tested in an experiment by Morgan and Bakan (1965) Sixteen male and twenty female subjects were subjected to an hour of perceptual deprivation Half of the sample spent the hour lying down in a horizontal position while half were sitting up Twelve subjects were assigned to each of three report conditions continuous reporting voluntary (report from time to time) and silent conditions (delay report until after the experiment) Twelve of eighteen subjects gave some hallucinations in the horizontal position while only three of eighteen gave these phenomena in the sitting position The difference was significant. No relation was found between vividness of hallucination and position Report method anxiety (measured by Taylor s MAS scale) sex of the subject and daydreaming and nonhallucinatory imagery were not significantly related to hallucinatory occurrence or vividness

LEVEL OF AROUSAL DURING RVSs

A crucial issue concerning the RVS phenomena concerns the level of arousal at the time RVSs occur The theories of Scheibel and Scheibel (1962) and West (1962b) suggest that RVSs in sensory deprivation conditions are most likely to occur in a subject who is awake aroused and perhaps anxious Freedman and Greenblatt (1960) feel that RVSs are hypnagogic or hypnocampic images and are most likely to occur in drowsy states between waking and sleep Ziskind (1965) also feels that visual imagery in sensory deprivation is a function of periods of reduced awareness or drowsiness The theory of Evarts (1962) would suggest that light sleep would be the most characteristic state in which RVSs might occur

The EEG is the most reliable method of determining the stage of arousal because it shows characteristic changes in waking and sleep states Heron (1961) presented some EEG data concurrent with an RVS period in one of his subjects The data indicate alpha blocking patterns of alertness at the time just prior to RVS reports Leiderman (1962) presented EEG data on two RVS subjects who reported eight RVSs between them The EEG shows the RVSs occurring either in waking or drowsy states Short and Oskamp (1965) found significantly more eye movements and alpha blocking during reports of visual imagery than during other periods of verbalization and concluded that SD imagery occurred during periods of alertness" Marjerrison (1966) investigated the reputed imagery

facilitating effects of Pheniprazine in chronic schizophrenics They found that increase in amount of visual imagery in a Ganzfeld situation seemed to depend on a drug effect of enhanced cortical activation (desynchronized, fast wave beta)

Rossi, Furhman, and Solomon (1964) criticized prior studies because they felt that the RVSs may have been dreams whose report was postponed until the subjects reached levels of arousal suitable for making reports They took EEG recordings and instructed subjects to report on signal The signals were given on a random schedule to three subjects The greatest proportions of reports of RVSs were obtained when the subjects were signalled while in EEG sleep stages No RVSs were obtained when the EEG indicated that the subject was awake

Zuckerman and Hopkins (1966) have criticized the Rossi study on the basis that waking RVSs are an infrequent phenomena and unlikely to coincide with a random signal occurring only three times per hour During certain stages of sleep such signals are much more likely to coincide with a dream report Because of this sampling bias it was felt that a combination of spontaneous reporting and continuous EEG recording was the only appropriate method for investigating this problem

Zuckerman and Hopkins tested 22 student nurses in an hour of sensory deprivation Samples of the EEG records were rated on an arousal scale for each subject Ten of the 22 girls gave RVSs sometime during the hour Figure 4–1 shows the EEG arousal ratings of these individual subjects together with the point of occurrence of the RVS report RVS subjects 1 to 3 were initially awake and aroused, but sank gradually into sleep over the course of the hour In all three cases all of the RVSs were reported during the waking phase of the hour Subjects 4 to 8 remained awake through the entire hour, and all reported RVSs at various times during the hour Subjects 9 and 10 were drowsy for most of the hour without actually falling asleep Subject 9 reported an RVS in the brief aroused state and continued to give them in the drowsy state Subject 10 reported RVSs in a sustained drowsy state Ratings of the 15 second parts of the EEG records just prior to RVSs yielded just two instances in which the EEG level was below wakefulness The subjects described their own state of arousal during RVSs in Leiderman's Post Isolation Imagery questionnaire (1962) 71 percent said they were fully awake, 14 percent reported being mostly awake, and 14 percent stated that they were drowsy when the RVSs occurred None said they were asleep at the time These results indicate that the typical spontaneously reported RVSs occur in waking or drowsy states This does not obviate the possibility that some of the phenomena reported *after* longer isolation periods may represent fragments of dreams or that subjects awakened in the REM stage of sleep will report dreams as images

Another interesting result of this study was that the RVS subjects asked to describe their isolation feelings on an affect adjective checklist

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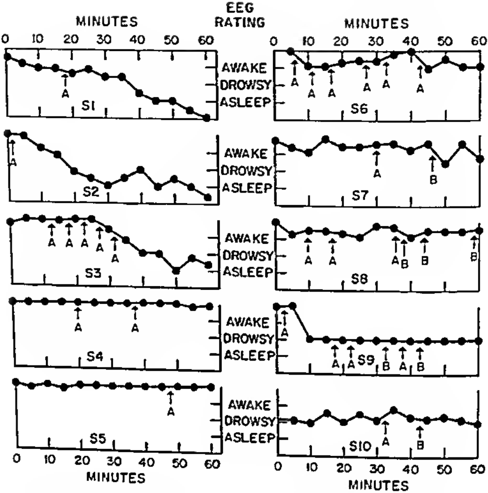


FIGURE 4–1 EEG arousal ratings and occurrence of RVSs for individual subjects

SOURCE Reprinted by permission from M Zuckerman & T R Hopkins *Percept mot Skills* 1966, 22, 447–459

measure scored significantly higher than NoRVS subjects on anxiety, depression, and hostility scales Previous studies (Morgan & Bakan, 1965, Zuckerman, Albright, Marks, & Miller, 1962) attempting to relate anxiety to RVSs have used trait measures such as the Taylor scale or pre to post isolation change measures A single state scale applied to the subject's experience while in isolation may be more relevant to West s hypothesis of a relationship between anxiety and hallucinations

Another interesting facet of these data is that RVS subjects made significantly more reports of all kinds and significantly more of them reported auditory and somesthetic sensations than non RVS subjects Zuckerman and Cohen (1964a) noted the relationships between RVSs and total verbalization in many studies It would seem that the RVS responses are one part of a general alertness to one s feelings and sensations during the

isolation period The relationship between RVSs and RASs was noted in a prior study (Zuckerman Albright Marks & Miller 1962)

The results tend to favor the hypothesis that most RVSs are not simply postponed dream reports but represent a mixture of idioretinal phenomena intensified images and waking and hypnagogic hallucinations The optimal state for RVSs seems to be a waking or an aroused one although if the subject is too aroused or panicky he may not be able to relax enough to attend to changes in his visual field

VOLUNTEERS VS NONVOLUNTEERS

Neither the HumRRO Group (Murphy Myers & Smith 1963) nor Short and Oskamp (1965) found any difference between volunteers for isolation and nonvolunteers required to participate for short periods in the incidence of RVS phenomena

SEX DIFFERENCES

Pollard Uhr and Jackson (1963a) found that male and female subjects reported about the same number of visual and auditory experiences Morgan and Bakan (1965) found no sex differences on RVSs Leiderman reported no significant sex differences in visual auditory or somesthetic images Data provided by Short and Oskamp (1965) and Walters Parsons and Shurley (1964) indicate no sex differences in RVSs using the water suspension method Arnhoff and Leon (1963b) compared males and females on a score called imagery disturbance and found no differences Reed and Kenna (1964b) found no significant sex differences on bodily orientation sensations

The only suggestions of sex differences in RVSs were in the study of Zubek Pushkar Sansom and Bowing (1961) where ten of twelve male subjects gave RVSs while only one of four females reported RVSs and in the comparison of male and female groups in Zuckerman Levine and Biase (1964) and Biase and Zuckerman (1967) where more males than females gave Type B RVSs There were no sex differences in the total RVSs of both types or in auditory kinesthetic or somesthetic sensations reported in the Zuckerman and Biase data Zuckerman Persky Link and Basu (1968a) found no sex differences on the Myers Questionnaire RVS scale given after 8 hours of sensory deprivation

PERSONALITY DIFFERENCES

Goldberger and Holt (1961a and 1961b) studied two groups consisting of 14 undergraduate males and 16 male actors with the purpose

finding personality characteristics related to responses to perceptual isolation In the undergraduate sample imagery in isolation correlated positively with tests and interview based ratings measuring acceptance of one s passive feminine side intellectual flexibility breadth and richness and freedom from emotional disturbance or constriction However in the actor sample masculine rather than feminine values and attitudes correlated with imagery Variables from the other two clusters were correlated with imagery in the actor sample but only one measure of intellectual flexibility and one measure of neuroticism correlated with imagery in both samples The latter was Block s Neurotic Under Control scale which correlated negatively with imagery Imagery was also correlated with a group of scales that denoted being a good subject cooperativeness and persistence Imagery tended to be correlated with other reactions to isolation which were termed adaptive In the undergraduate group imagery correlated positively with verbalization ($r = 87$) and in the actor group it correlated negatively with sleep ($r = -68$)

Silverman Cohen Shmavonian & Greenberg (1961) and Cohen Silverman and Shmavonian (1962a) compared field independent and field dependent subjects as defined by scores on the Rod and Frame Test of Witkins (1954) and the Draw a Person Test They report that more of the field-dependent group responded with hallucinatory like phenomena

Cambareri (1959) used a battery of suggestibility tests to divide his subjects into high and low groups The author combined all scores in a single score Because these tests were uncorrelated there was no basis for assuming that they were measuring a common trait or for combining them Whatever the combination score measured it was highly related to RVSs because nine of ten high scoring subjects reported them whereas only two of ten low scoring subjects gave them

Leiderman (1962) found that somesthetic imagery was negatively and significantly correlated with a complexity score based on the Draw a Person Test The Gottschaldt Test of the ability to pick a figure out of an embedded field (field independence) tended to correlate positively with imagery This finding would be in the opposite direction theoretically from that of the Silverman group who found that field dependents gave more RVSs The Stroop test which also seems to measure a type of visual field independence or ability to resist distraction correlated positively and significantly with auditory and somesthetic imagery

Solomon and Mendelson (1962) and Zuckerman Albright Marks and Miller (1962) found no relations between scores of the MMPI and EPPS tests and hallucinations in sensory deprivation Stewart (1965) found no personality differences between subjects reporting and those not reporting visual imagery in a brief 10 minute perceptual deprivation situation He used the Embedded Figures test of Field Dependence Independence IPAT 16 P F MMPI and other tests

INTELLIGENCE AND AGE

Goldberger and Holt (1961b) found a positive correlation (r = 59) between intelligence as measured by the Ohio State Psychological Examination and imagery in their undergraduate sample Murphy Myers and Smith (1963) found no relation between their measure of intelligence and during isolation RVSs In one of the groups they found that the more intelligent Ss produced significantly less complex RVSs as reported on the postisolation test Zuckerman Albright Marks and Miller (1962) Leiderman (1962) and Morgan and Bakan (1965) found no relation between RVSs and intelligence In the latter study hallucinating subjects were found to be significantly younger than nonhallucinators (18 vs 21 years)

COMPARISONS OF SENSORY DEPRIVATION HALLUCINATIONS WITH PSYCHOTIC AND DRUG INDUCED HALLUCINATIONS

Malitz Wilkens and Esecover (1962) have presented data on 100 randomly selected chronic schizophrenic patients and 57 acute psychiatric patients and 42 normals administered one of three drugs d lysergic acid diethylamide (LSD) d l methyl lysergic acid diethylamide (MLD) or d l acetyl lysergic acid diethylamide (ALD) The case histories of the 100 chronic schizophrenics revealed that 50 percent of them experienced auditory hallucinations whereas only 9 percent showed visual hallucinations Most of the auditory hallucinations of psychotics consist of voices corresponding to Type B RASs Although some subjects in sensory or perceptual deprivation experiments report hearing voices or music the median percentage in the studies reviewed in Table 4–1 was only 15 percent

The subjects receiving drugs reported predominantly visual hallucinations LSD 40 percent of patients 72 percent of normals ALD 55 percent of patients 91 percent of normals MLD 10 percent of patients 62 percent of normals There were only a few dubious reports of auditory or other type of hallucinations in patients or normals receiving the drugs It would appear that sensory deprivation hallucinations are unlike psychotic phenomena in the rarity of auditory hallucinations. The content of the drug induced visual hallucinations was similar to the RVS phenomena of sensory deprivation (e g abstract and geometrical forms lattice work flashes and human animal and familiar forms) The percentages of normal subjects reporting conventional forms and objects under drugs (28 percent for LSD 36 percent for ALD and 31 percent for MLD) are in the percentage range of Type B RVS phenomena reported in Table 4–1 although somewhat higher than the median of 19 percent Most of the drug induced abstract hallucinations were in vivid colors but only 39 percent

of the RVSs reported by the subjects in the Zuckerman and Hopkins (1966) experiment were in color

Cohen, Silverman, and Shmavonian (1962a) compared the responses of five subjects given 2 hours of SD after taking LSD, with five subjects put in SD after taking a placebo The EEG, GSR, heart rate, and adrenal hormone measures indicated greater arousal in the LSD group Although all subjects in both groups reported visual sensations "the LSD subjects saw more vivid visual phenomena and more detailed visual imagery than the control group (p 274)

Kluver (1942) described certain types of visual figures invariably seen during the development of hallucinations stimulated by mescalin lattice work, cobwebs tunnels spirals, and geometric shapes These types of RVSs are frequently given by sensory deprivation subjects

Feinberg (1962) has enumerated some of the differences between schizophrenic visual hallucinations and drug induced hallucinations (1) The schizophrenic hallucinations appear suddenly and without prodromata, while those of mescalin and LSD follow RVSs of an noncomplex variety, such as geometrical figures and abstract patterns (sensory deprivation RVSs also show this progression) (2) Schizophrenic RVSs occur during states of intense affect or delusion while drug induced RVSs develop independently of affect, or produce affect as a response to the RVS (3) Schizophrenic hallucinations may be superimposed on a visual environment that is otherwise normal, while drugs produce diffuse distortions of the existing visual world (4) Schizophrenic hallucinations are generally seen with the eyes open whereas drug induced hallucinations "are more readily seen with the eyes closed or in darkened surroundings" The last statement is interesting in that it suggests that the drug and sensory deprivation phenomena may both depend partly on reduced perceptual input and this may account for their similarity Feinberg also comments on the rarity of visual hallucinations in patients, estimating 3 to 4 percent in the admission wards of a state hospital

Bliss and Clark (1962) qualitatively compared hallucinations produced by LSD, mescalin alcoholic delirium tremens, schizophrenia, sleep deprivation and sensory deprivation They believe that sensory deprivation hallucinations normal intense imagery, hypnotic phenomena, and psychotic hallucinations may be grouped in one category, hypnagogic states dreams and sleep deprivation phenomena in another, and the drug induced hallucinations in a third Reading the examples of each type of hallucination one could argue with this categorization of the phenomena Schizophrenic hallucinations contain many religious supernatural figures or symbolic figures and objects while drugs seem to produce many colored patterns and geometric forms much like the more typical Type A RVSs in sensory deprivation

It would appear that the most of the RVS phenomena of sensory deprivation are more similar to drug induced hallucinations than they are

to psychotic hallucinations Some of the drug induced illusions seen with the eyes open involve distortions of shapes much like those reported by the McGill investigators immediately after emerging from perceptual isolation

The similarity of drug induced hallucinations and sensory deprivation RVSs may be related to the action of the drug like LSD which impairs normal sensory transmission (Marrazzi 1962) but at the same time increases the level of arousal (West 1962b)

Phencyclidene (Sernyl) is a drug which has been said to produce psychological symptoms like those in schizophrenia by limiting and selecting sensory input Lawes (1963) exposed a small group of subjects given Sernyl to mild social stress consisting of an interview and testing session a sensory deprivation situation and a simple confinement situation They found that the drug produced major disturbances when the subject was under mild social stress including illusions and body image changes but there was little disturbance of psychological processes in sensory deprivation The incidence of RVS phenomena was not reported so that the bearing of these results on the Perceptual Release Theory (West 1962b) cannot be evaluated A similar experiment by Cohen Luby Rosenbaum and Gottlieb (1960) came to similar conclusions about the combined effects of Sernyl and sensory deprivation although in this experiment one of the five subjects reported a vivid hallucinatory experience

SUMMARY

Certain hypotheses have been advanced concerning the variables in sensory or perceptual isolation situations which may facilitate or inhibit these phenomena A look at the evidence tends to refute some of these hypotheses and support others

1 *RVS phenomena are facilitated by constant* homogeneous stimulation and inhibited by absolute reduction of stimulation (Heron 1961) (Hypotheses refuted by preponderance of evidence Both types of simple invariant sensory fields produce more RVSs than do more complex and varying sensory environments)

2 *Intermittent visual stimulation in a sensory* deprivation situation facilitates RVSs (Vernon McGill & Schiffman 1958) (Studies show intermittent stimulation neither facilitates or inhibits RVSs)

3 RVS phenomena are facilitated by confinement of motility and inhibited by activity (Freedman Grunebaum & Greenblatt *1961*) *(Hypotheses generally not supported although crucial experiments needed)*

4 Complex RVS phenomena only appear after a long period of isolation (more than a day) and become more frequent as time in isolation progresses

(Most studies where subjects are told to report these phenomena during isolation show that such reports are most frequent in *the first hours of isolation*

and diminish rather than increase in frequency with time, or else show no effect of the amount of prior deprivation Using postisolation reports, a relationship with duration does appear and a 24 hour isolation period is usually necessary to achieve RVS complexities greater than in normal, nondeprived baseline conditions)

5 The reclining position facilitates RVSs (Zuckerman & Cohen, 1964a) (Thus far supported by one study (Morgan & Bakan 1965) specifically testing this hypothesis)

6 RVSs typically show a progression from simple, unstructured, meaningless sensations to more complex structured meaningful ones (Heron 1961) (Supported by most studies including Zuckerman and Cohen (1964b) and Murphy, Myers and Smith (1963) where the progression furnishes the basis for Guttman scaling of RVS complexity)

7 RVSs are encouraged by prior information or expectancies of such phenomena (Jackson & Pollard 1962) (Not supported by studies where experimenters explicitly inquired into subject s knowledge and expectancies)

8 RVSs are encouraged by experimental sets contained in the instructions given to subjects or the accoutrements of the experiment (Jackson & Pollard, 1962) (Findings are mixed but there is some indication that only the least complex and meaningful RVSs are vulnerable to such influence)

9 RVSs are facilitated by continuous reporting instructions and inhibited by reporting delayed until the end of the experiment (Zuckerman & Cohen, 1964a) (Evidence mixed RVS subjects tend to report more phenomena of all types and the use of postisolation reports alone yields small numbers of such reports but Morgan and Bakan (1965) find no difference in results from different report methods)

10A RVSs are most likely to occur in states of high arousal (West, 1962a)

10B RVSs are most likely to occur in states of medium arousal or drowsiness (Freedman & Greenblatt, 1960)

10C RVS are most likely to occur as dream phenomena in states of low arousal or light sleep (Evarts 1962)

(The evidence on these opposing hypotheses is mixed, but concurrent EEGs and spontaneous reporting of RVSs indicates that they typically occur in states of high or medium arousal even when such states are not preceded by periods of sleep)

11 RVSs are facilitated by anxiety (West, 1962a) (Evidence mixed Generally anxious subjects produce no more RVSs than nonanxious subjects Only Zuckerman and Hopkins (1966) and Cohen Silverman, & Shmavonian (1962a) show some relationship between RVSs and anxiety or maladaptive responses during isolation)

12 RVSs are typical of specific personality types (No conclusive evidence Positive results have not held up on replication or have not been replicated Concepts of field dependency are worth pursuing)

13 RVSs are like psychotic and drug induced hallucinations (Most psychotic hallucinations are auditory while auditory hallucinations of voices are rare in sensory deprivation experiments. RVSs show more resemblance to drug induced hallucinations although the latter are more colorful vivid, and persistent Although an occasional RVS shows the characteristics of a psychotic

hallucination such as dimensionality belief of subject affect arousal and dynamic significance most seem to be *transient impersonal phenomena* of no dynamic or pathological significance)

The sensory deprivation hallucinations seem considerably less eerie than when they were first reported by the Canadian students Although considerably more study of them is needed a tentative formulation can be put forth at this time

When a subject is put in an environment without patterned and changing stimulation he may relax and fall into a state of lowered arousal and sleep he may focus attention on his thoughts or he may keep scanning his interoceptive and exteroceptive fields for stimuli Either an experimental set or his own sensitization to peripheral sensory changes may initially lead to reports based on idioretinal phenomena inner ear noise or illusions Eventually the subject may become sensitized to more organized images whose site of origin lies higher in the nervous system The discrimination between internal images and perceptions rests in the differential intensities and clarity of the phenomena as well as in the contextual cues from the environment Images may be intensified by a high state of arousal or by a reduction in competing stimuli Because the contextual cues from the environment are lacking in isolation experiments an intense image may be localized in space in front of the subject The subject s secondary reactions to such complex imagery will determine their persistence and whether or not he will report them in a postisolation report Sensitizing the subject to the phenomena by requiring some reports during isolation will tend to produce more complex reports after isolation

5

Changes in Intellectual Performance and in Susceptibility to Influence

Peter Suedfeld

This chapter reviews reports concerning the effects of sensory and perceptual deprivation as defined in chapter 2 on various information processing behaviors (The abbreviation SD will be used to refer to sensory deprivation perceptual deprivation and related techniques in general) Many SD phenomena involve changes in information processing here we will be concerned with effects on problem solving and on the response to persuasive inputs It is sometimes difficult to identify purely cognitive effects for example projective test responses may be interpreted as revealing either cognitive or affective states or both Such borderline cases will be treated only from the standpoint of intellectual efficiency Thus changes in coherence in speech rate and in story length will be discussed but changes in mood or in latent content will not In the consideration of attitude change the affective component of attitude will be ignored—a step facilitated by the unfortunate fact that all of the studies in this area ignore it too

INTELLECTUAL PERFORMANCE

Two major types of cognitive performance can be identified in the literature (cf Goldberger & Holt 1961c) One involves tasks which the subject sets for himself or which are part of his normal behavior The effects of deprivation on these tasks will be discussed under the heading Subject Initiated Behavior The two measures which have been em ployed in this context are subjective reports of cognitive change and word counts of spontaneous speech during confinement

In the section on Experimenter Initiated Behavior I shall deal with intellectual performances which are demanded by the experimenter That is learning or problem solving tasks are presented to the subject in order to measure cognitive change Here the indices used by SD research

The preparation of this chapter was made possible by a Biomedical Sciences Sup port Grant from the National Institutes of Health

ers are similar to those in the general cognition literature IQ scores trials-to-criterion scores and so on

Subject Initiated Behavior

Concern with the cognitive effects of SD began as did interest in most other deprivation phenomena with the amazingly fruitful work of the McGill group Their subjects reported that they were unable to concentrate could not think clearly and had difficulty in organizing their thoughts (Scott 1954 Scott Bexton Heron & Doane 1959) Later research has shown that this effect unlike so many others is not confined to a few laboratories A brief sampling of quotations will give us the flavor of the relevant data

Subjective Reports

According to experimenters using perceptual deprivation subjects report difficulty in thinking coherently and in concentrating (Freedman & Greenblatt 1960) thoughts hopping around (Goldberger & Holt 1958) mental clouding (Courtney Davis & Solomon 1961) Other reports from these laboratories and the findings of other researchers (Smith & Lewty 1959 Ohkubo & Kitamura 1965 Rosenzweig & Gardner 1966) agree Furthermore Zubek (1964a) indicates that among subjects released after 14 days of perceptual deprivation inability to study or to engage in a variety of activities persisted for up to 8 days the mean for ten subjects being 3¼ days

Confinement in a tank respirator in an illuminated room has been a much less widely used technique Its foremost practitioners have stated Most subjects reported that while in the respirator they lost the ability to concentrate on specific ideas especially abstract problems and mental arithmetic (Wexler Mendelson Leiderman & Solomon 1958) Other experiments in the same laboratory have replicated this result (Davis, Mc Court & Solomon 1960 Mendelson Kubzansky Leiderman Wexler & Solomon 1961) Pollard Uhr and Jackson (1963a) although they did not use a respirator achieved the effect of one with a dome which enabled the subject to see a small patterned area the part of the face which is in the visual field A few subjects reported difficulty in thinking being unable to concentrate for any extended period of time many thoughts were going through their minds in a rapid and uncontrolled manner After confinement in a respirator with white noise but in a dark room concentration was again reported to be impaired with a confined but nondeprived control group falling between the experimental and the ambulatory control groups in reporting such disturbances (Zuckerman Albright Marks & Miller 1962)

The results of water immersion are unanimous Again this technique is not frequently used Lilly (1956) who originated it reported

that both of his subjects experienced the phenomenon, Barnard, Wolff, and Graveline (1962) indicate that seven of their ten subjects described their thought processes as 'being rapidly accelerated, moving rapidly from one subject to another The most productive user of this method, Jay T Shurley, has written "the inability to maintain directed thinking [was] especially impressive (1963) One of his subjects, for example, had planned to prepare a report and a budget during his time in the water tank but did not manage to accomplish either (1960) Goldberg (1961) indicates that some of his subjects reported difficulty in concentrating during a 2 hour immersion period

Sensory deprivation, a very extensively used method, usually has yielded similar statements Just over half of the subjects of Zubek, Sansom, and Prysiazniuk (1960) had difficulty in concentrating, experimental subjects in the studies of Freedman and Greenblatt (1960) and of Myers Murphy, Smith, and Windle (1962) also felt that their thought processes were less efficient than usual Ruff, Levy, and Thaler (1961) describe a consistent pattern of changes in the thought process "Subjects usually plan to do some creative thinking but soon find they have no desire to concentrate Instead thoughts drift through the mind in random sequence' Weinstein, Richlin, Weisinger, and Fisher (1967) report that 48 percent of their subjects found difficulties in thinking "their thoughts were jumbled, i e they could not clearly organize their thoughts and this lack of clarity was beyond their control Ten percent reported that the effort involved in thinking clearly was too great, and that they simply gave it up'

Incidentally, this statement (as well as that of Ruff, Levy, and Thaler, 1961, quoted previously) is a good example of the tenuous line between cognition and motivation Many confined people say that concentrating was 'too much trouble Is the disturbance an intellectual one or not? This may be at most a distinction without a difference, at any rate with no operational way to distinguish, it will be ignored in this chapter

At the Princeton SD laboratory, Vernon and Hoffman (1956) reported an explicitly negative result although their subjects were specifically asked about lack of ability to engage in extended thought In each case the subject s report was contrary to the McGill findings However, there were only four subjects in this study, in the experiment whose technique was the most similar to Vernon and Hoffman s (Zubek Sansom, & Prysiazniuk 1960) there were seven negative reports but nine positive ones With a larger number of subjects the Princeton researchers too, might have found positive instances

One point which should be mentioned here is that some investigators ask their subjects whether they had found difficulty in thinking or concentrating others ask for reports of unusual experiences or feeling in general still others ask for nothing recording only spontaneous com

ments It is deplorable that the procedure in this regard is frequently left unspecified so that even an unusually well quantified statement like X percent of the subjects reported difficulty in concentrating' is difficult to interpret If the reports are in response to a pointed query they represent the maximal proportion of recognized cognitive impairment but if they are completely spontaneous they may account for only a small percentage of such occurrences After all a sensorially deprived person has gone through a very unusual experience and just may not consider cognitive effects important enough or dramatic enough to bring up unless he is asked The fact that the reports are usually (although not always) made after release is also important concurrent reporting may prevent forgetting of some relevant instances which may then be elaborated in detail during postrelease questioning (On the other hand the question itself may prompt a spurious or exaggerated recollection)

In spite of these problems it seems generally true that subjects in the various deprivation environments tend to experience disturbances in thinking and particularly in thinking about any one topic for a prolonged period From the data it is not possible to estimate the magnitude (as contrasted to the commonality) of impairment [There are data] suggesting wide individual differences in the ability to rate thought processes These findings raise serious questions concerning the validity of results obtained in studies that have used Ss judgments at face value The confusion and contradictions that abound in the SD literature can be attributed at least in part to this apparent source of error (Rossi Furhman & Solomon 1967) Myers Murphy Smith and Goffard (1966) comment that Cubicle [SD] subjects reported greater difficulty in concentrating than did Control subjects which is curious since their actual performance was better on at least one of the tests greater difficulty in concentrating was reported by Cubicle subjects who had done relatively well on the tests

There are also striking differences among individuals as to the occurrence of the phenomenon This is shown not only by the existence of many subjects who do not report disturbances but even more dramatically by those few who comment on the improvement of their memories and by those who exhibit tenacious concentration in the pursuit of some self chosen task Among the former there were two subjects in a study by Zubek Sansom and Prysiazniuk (1960) both of whom emphasized the vividness of recall—particularly visual memory—during SD Lilly (1956) also reported the redintegration of long term memories and one of Shurley s subjects said Everything I thought of came to mind much more vividly than it would outside but I simply could not concentrate (1960) Suraci (1964) in a unique study subjected himself to 7 weeks of almost uninterrupted isolation bed rest and limitation of sensory input He too remarks upon the vivid recall of early memories.

While many people report doing problems and playing mental games during experimental sensory deprivation (Goldberger & Holt, 1958, Ruff, Levy, & Thaler, 1961), the concentration of one subject stands on an unapproached peak His case, reported by Vernon (1963, pp 67–70) brings to mind the almost incredible efforts of such prisoners as Edith Bone (1957) This student, instructed to estimate each hour of elapsed time, invented a Rube Goldberg method for doing so—a method which involved using an apple and a length of electric wire (fortunately not connected to any vital instruments) to construct a pendulum by which, via Newton's Second Law of Motion, he timed his own heartbeats which he then proceeded to count for 2½ days Of course he did make this task easier by inventing an abacus, using patterns of nails in the beaverboard-covered wall, to keep track! But while we must admire his ingenuity and persistence, it must be pointed out that this was not concentration in the purely intellectual sense, he was manipulating objects and later following a self-established ritual, both very different tasks from lying around and 'just thinking'

SPONTANEOUS VERBALIZATION

From Lilly's (1956) description of "stimulus-action hunger, we would expect that deprived subjects would be eager to gain auditory and proprioceptive stimulation by talking Since they are also socially isolated, we would also expect them to want to prolong communication with the outside world as represented by the listening experimenter (Gibby, Adams & Carrera, 1960, Cohen, Silverman Bressler, & Shmavonian 1961, Ruff, Levy, & Thaler, 1961, Gorbov, Miasnikov, & Yazdovsky, 1963, Oyamada & Sato 1965) This prediction would also hold if instead of a social or affiliative drive, we posited anxiety arousal as a result of social isolation (Brown, 1963, Walters & Karal 1960, Weinstein, Richlin Weisinger, & Fisher, 1967) The only theoretical viewpoint which would not predict such an effect is that which interprets isolation as frustrating dependency needs (Sears Whiting Nowlis, & Sears, 1953, Whiting & Child, 1953) dependency is probably never higher for a healthy adult person than when he is in SD (Azima, Vispo & Cramer Azima 1961)

Data bearing on the hypothesis are scarce and agree mostly on the high variability of verbal output Mendelson et al (1960) rated the verbalizations of their respirator-confined subjects every hour for from 3 5 to 30 8 hours of confinement The rating scale ran from 0 (no verbalization) to 3 (marked verbalization) Ratings ranged from 0 1 to 2.5 Barnard Wolff and Graveline (1962) reported a range of from 8 to 209 (!) statements among ten Air Force pilots immersed in water for 10 hours each, and among the subjects of Davis McCourt, Courtney and Solomon (1961), who were confined in pairs—so that social isolation did not exist—variability in verbal output was also quite high

Aside from magnitude of variability there are few consistent find ings Pollard Uhr and Jackson (1963a) found no difference between the verbal productivity of experimental and control subjects. Shurley (1960) indicated that during a 4¼ hour period of immersion his subject never kept quiet for even as much as six consecutive minutes but 15 of the 20 subjects of Freedman and Greenblatt (1960) experienced inability to talk (no quantitative measure was employed) Myers Murphy Smith and Goffard (1966) note that their confined subjects talked surprisingly little As to the quality of speech Mendelson et al (1961) stated that their subject had difficulty in expressing himself coherently although there was no objective measure and Cohen Silverman Bressler and Shmavonian (1961) say In the first 5–20 minutes of the initial interview [after a few hours of sensory deprivation] the speech of the subjects was often slurred and the grammatical structure of their sentences indicated a disorganized and perplexed state

Thus while some data imply that like thinking speaking becomes less efficient as a result of SD the evidence here is not nearly so strong From subjective reports it does appear that deprived individuals feel a desire to talk While the motivational explanations of this finding are fairly clear its cognitive implications are ambiguous The relationship between amount of output on the one hand and coherence clarity or concentration on the other has never been established A person who talks a lot may demonstrate a high level of concentration and thought or he may be babbling incoherently or skipping from topic to topic High output *per se* therefore probably cannot be interpreted very confidently as a sign of either high or low intellectual efficiency

It also seems that verbal behavior is subject to adaptation effects Pollard Uhr and Jackson (1963a) compared the verbal output of a group undergoing semiperceptual deprivation for 8 hours with the output of the same subjects during a second 8 hour confinement period approximately a week later They found that the average number of words spoken dropped from 1 087 to 446 upon repetition of the experience a significant change in spite of high variance When before the first 3 hour confinement of a related experiment the subjects were told to expect such effects as difficulty in concentrating and before the second (again a week later) were in formed that a pill they had just been given might counteract these effects, the mean word count again dropped significantly (from 1 800 to 358) In both of these two sessions however output was higher than during the first 3 hours of the repeated 8 hour sessions mentioned previously If we agree with Pollard and his co-workers that high output is a consequence of SD then we can also agree that (a) people adapt when deprivation is repeated diminishing its effects and (b) suggestion as to what to expect increases the impact of deprivation—apparently even when the suggestion is that the effects might not occur!

The data of the Pollard study may throw some light on the meaning of changes in verbalization, since not only words but also the number of discrete statements were counted If high output means good concentration then the word/response quotient should be high, if high output means poor concentration then the quotient should be low It is possible to calculate these quotients from the raw data which are presented for the repeated 8 hour experiment, the average number of words per response increased from 35 75 to 42 80 This nonsignificant trend implies that spontaneous high output is associated with poor concentration, and that cognitive efficiency improves as one adapts to SD The logical conclusion is that SD itself damages efficiency

In general psychological theory and common sense both predict that SD raises the desire to think and to speak, but, at the same time, it appears that deprivation techniques disrupt the organized flow both of intrinsically motivated cognitive behavior and of its overt indicator, speech

The findings are reasonably consistent across studies, many subjects experience such disruption Wheaton (1959) may have been too sanguine when he listed inability to think either long or clearly as one of the stages of a general sensory isolation syndrome , but if there really were such a syndrome (nobody seems satisfied that one has been identified), this stage would certainly be as well documented as the best of the rest

Experimenter Initiated Behavior

Although subjective reports of cognitive impairment were so frequent, there was no way to specify either the exact nature or the magnitude of the effect In order to identify just exactly which intellectual functions were hindered by SD and to what extent, many researchers have administered a great variety of tasks to their subjects

Perhaps the most frequently used problems are those taken from standard intelligence or achievement tests, and *ad hoc* adaptation of such items Measures of learning and memory have also been administered in a number of studies The use of unstructured tasks such as projective techniques is rarer, but, as will be explained later, such experiments have a particularly important role Let us look at the results of these different types of indices in order of frequency of use

OBJECTIVE TEST ITEMS

The number of different items used by SD researchers makes it difficult to evaluate so unitary a concept as the cognitive effects of SD ' The difficulty is aggravated by the fact that different investigators use different versions of a test a procedure which in itself can lead to variable results For instance ' mental arithmetic may refer to the addition of pairs of small numbers or it may mean complex successive arithmetical manipulations We can hardly be surprised if the subsequent data are incon

sistent Furthermore different labels sometimes disguise the same test e g what Goldberger and Holt (1961c) call serial sevens is termed successive subtraction by Myers Murphy Smith and Goffard (1966)—and it s still arithmetic Throughout this section generally understood test labels are used not necessarily the ones used by the original researchers

In his tabular summary of the literature Schultz (1965) demonstrates the lack of agreement within tests and across reports While this variability may be due to systematic experimental manipulations or to fluctuations in the phenomenon we must bear in mind the contaminated nature of the measures

The measurement of cognitive change has taken two major forms comparisons of pre-confinement scores with during and post confinement scores on identical or equivalent tests and comparisons between the scores of deprived subjects and those of various types of control groups In the own-control case the problem of intergroup differences in ability is avoided but questions about test retest reliability or form equivalence must be answered With intergroup comparison designs the opposite is the case Intergroup differences pose a particularly knotty problem if the control subjects are recruited on a different basis from the experimentals Clearly people who volunteer for SD may differ in many ways from people who volunteer to take some tests The appropriate treatment of control groups is another poser and one which has occupied an important place in the SD literature (see chapter 2)

Some researchers have used a combination of the two designs changes over time (test retest) in an experimental group are compared to changes in one or more control groups so that significance tests refer to differences between differences It seems to me that this combinatorial design incorporates the weaknesses of both approaches and dilutes the strength of each but while the reliability of an interpretation based on such comparisons may be attenuated its meaningfulness and relevance are probably high That is results showing that deprived subjects changed more than or in a different direction from controls are likely to identify a real SD phenomenon At the same time because of the unmeasurable interplay between sampling errors and retest effects such results may be to some extent contaminated With these *caveats* let us look at the data

One of the most global reports of changes in cognitive performance was that of Adams (1964) In this experiment 30 psychiatric patients were confined in a dark silent chamber for 6 hours each Wechsler Adult Intelligence Scale IQ s rose from an average of 97 before the experimental session to 104 after release With normal subjects Robertson and Wolter (1963) reported that WAIS IQ s went up for controls (as did subtest scores on similarities and both verbal and performance IQ s) but not for experimentals undergoing 3 hours of sensory deprivation The deprived group did improve in picture completion object assembly and performance

IQ, indicating perhaps that tasks in which perceptual-motor variables were important differed from more purely cognitive tasks in their relation either to SD or to retesting (cf. the improvement of *visual* memory discussed before). None of the full-scale or subtest differences between the groups was significant.

On more specific investigations, variable results have appeared. The McGill group (Bexton, Heron, & Scott, 1954; Scott, Bexton, Heron, & Doane, 1959) compared pre-, during-, and post-session changes in the performance of experimental and control subjects, the former having undergone 2 to 3 days of perceptual deprivation. They found that differences between the groups were not significant on arithmetic problems, mental multiplication, making words from the letters of a given word, and completing number series; deprived subjects showed significantly greater decrements than controls on the Kohs Block Design Test. Scott, Bexton, Heron, and Doane (1959) point out that a trend toward greater impairment in experimental subjects was found in all of the nonsignificant data cited, as well as on analogies and anagrams. After 24 hours of deprivation, significant differences existed on the number series task, word making, and anagrams, with confined subjects showing greater impairment. These differences did not reach significance when changes from before deprivation to after release were compared. As we shall see, there are other data which indicate that (a) some adaptation takes place after 24 hours, so that cognitive decrements are thereafter alleviated, and (b) postrelease testing generally reveals smaller effects than testing during the session, regardless of duration.

Zuckerman, Albright, Marks, and Miller (1962), whose sensorially deprived subjects were confined in an iron lung, compared performance after 6½ hours with those of two control groups—one confined and isolated, and one ambulatory. On word naming (naming as many words beginning with a given letter as possible in 2 minutes), the experimental group showed a significant impairment compared to the two control groups. On mental arithmetic (addition, subtraction, or multiplication), there was no significant difference among the groups, although the confined control group had improved its performance. In another sensory deprivation study, Vernon (1961) found that experimental subjects took a mean of 41 trials to solve the concept formation problems of the Holsopple Test. The average number of trials for the control group was ten, significantly fewer. The Russian investigators, Gorbov, Miasnikov, and Yazdovsky (1963), reported cryptically (at least in translation) on the results of a complicated number-manipulating "game" which, when played by subjects confined in dark rooms during 10–15 days, indicated decreased efficiency.

In 1961, Davis, McCourt, Courtney, and Solomon used the iron lung–dark room technique, but placed two respirators in the same room.

They found that when two male strangers were confined together their performance on the Wechsler Digit Symbol subtest showed a decrement But when the respirators were occupied by husband and wife no such effect appeared—another of the many advantages of the wedded state! In another respirator study Davis McCourt and Solomon (1960) found poorer performances after than before confinement on the Digit Symbol but no change on Block Design and Hidden Figures

Courtney Davis and Solomon (1961) whose 18 subjects underwent four hours of sensory deprivation found that 14 showed deterioration on the Smith Beecher Arithmetic Test (simple addition) On the Wechsler Bellevue Digit Symbol 14 subjects again did worse than they had under control conditions Both of these changes were significant There was no difference between two subgroups one of whom had to perform sit ups and the other finger movements on signal during the session This study is unusual in that it resulted in significant differences even though the tests were administered after the subjects were released—a procedure which as a rule fails to demonstrate reliable SD effects In view of the short duration of confinement the interruptions provided by the exercise signals and the lack of a nonconfined control group the findings should perhaps be viewed with some caution

In one of the two water immersion studies to use objective problems Goldberg (1961) administered equated batteries of tests before and after 2 hour sessions Each battery included twenty information questions seven sentence building items seven logical deductions and twenty analogies no significant changes were found In the other study Barnard Wolff and Graveline (1962) came to the same conclusion on the Watson Glaser Logical Deductions subtest five subjects improved and five deteriorated after immersion on the Robinson Rhymes Test the respective figures were four and three with three other subjects evidencing no change These data are particularly striking in view of the fact that many people evaluate the water immersion technique as the most potent and effective producer of SD effects The timing of the posttests (see previous paragraph) may have affected the results in these cases

Pollard Uhr and Jackson (1963a) administered tests to both experimentals and controls and compared performance changes during two 8 hour sessions a week apart Neither on word making (from the letters of a given eight letter word with a 2 minute time limit) nor on 20 two-digit addition/subtraction problems were there anything but test retest effects Both groups showed significant decrements but not significantly *different* ones on the Watson Glaser Critical Thinking Appraisal Test

Goldberger and Holt (1961c) and Goldberger (1966b) confined unemployed actors in perceptual deprivation for 8 hours each using the placebo group in a drug (LSD) study as controls—a questionable procedure since placebo subjects may behave very differently from untreated

controls (that of course, is the whole rationale of a placebo group) To make it even worse, as the authors point out, the "control subjects' sat quietly in a dimly lit room, sometimes alone, thus undergoing an experience not too different from that of the deprivation group Not surprisingly, there were no differences between these two groups The LSD group did show significant impairments, thus contradicting the idea that the effects of LSD and those of SD are the same The tests used in this study included comprehension of long and of short passages word naming (words with a prescribed number of letters) "serial sevens' (counting backward by sevens from a specified number), giving words that rhyme either with 'fist or with 'rise, and Robinson's Rhymes Test and Number Test (The former of these is a more difficult rhyming task than the 'fist rise problems and the latter essentially consists of simple algebraic equations with one unknown)

Next we turn to a list of the findings obtained under the auspices of the Human Resources Research Office (HumRRO) As reported by Myers Murphy, Smith and Goffard (1966), subjects were tested 19 hours before confinement, as well as during and after the 76-hour sensory deprivation session Ambulatory controls were tested at the same time intervals No significant differences between the groups appeared in mental arithmetic nor in 'inductive reasoning (coin-changing problems), the experimental group did worse in reading comprehension, in listing words beginning with a given letter, and in successive subtraction (the serial sevens of Goldberger & Holt, 1961c) Unfortunately, there were uncontrolled pre isolation differences between the groups When intelligence was used as a second independent variable, the higher intelligence groups did better regardless of treatment, there was no interaction between SD and intelligence One important fact must be noted in this, as in the other HumRRO studies all of the subjects were at least at the 60th percentile of Army recruits in intelligence, so that even the lower group was fairly intelligent

A bugle call heralding a new approach to the study of cognitive effects was sounded by Goldberger and Holt in 1958 They administered equivalent forms of the Otis Arithmetic Reasoning subtest and the Watson Glaser Critical Deductions subtest before and again at the end of 8 hours of perceptual deprivation While no change was found on arithmetic reasoning, critical deductions showed a significant SD-connected deterioration On the basis of this datum the authors concluded that SD maximally impairs those performances which require active reflection and manipulation of ideas'

This formulation was the first to bring some order into the chaotic area of SD and cognition, but later studies showed that the finding on which it was based was contaminated Goldberger and Holt themselves (1961c) reported that the two forms of the Watson Glaser which they had

used as pre and post confinement tests were not really equivalent (the use of a control group would have shown this at once) Using the same test Pollard Uhr and Jackson (1963a) found that both experimental and control subjects did worse on a re administration showing decrements of about the same magnitude This demonstrated the lack of reliability of the original Goldberger and Holt data As we shall see however the conclusion itself was not necessarily wholly wrong even though its empirical basis crumbled in this instance

To cap off the review of objective testing let us turn to the most meticulous series of parametric studies in the field the work of Zubek and his associates at the University of Manitoba In the various parts of this series (whose results are summarized in Table 5-1) these experimenters used sensory deprivation (Zubek Sansom & Prysiazniuk 1960) perceptual deprivation (Zubek et al 1962) perceptual deprivation in conjunction with required exercise (Zubek 1963a) and bodily immobilization in a coffin like box (Zubek & Wilgosh 1963 Zubek et al 1963 Zubek & MacNeill 1966) using both confined (recumbent) and ambulatory controls Tests were administered in written form during interruptions of the experimental condition The groups were matched on pre-experimental performance In Table 5–1 the notation C > E means that the change in the performance of the control groups was significantly further in the direction of improvement than that in the performance of the experimental groups Incidentally it is interesting to note that the recumbent position in itself resulted in no significant differences from the ambulatory control treatment—in comparison each of the four subjects in the first pilot study

TABLE 5 1 Summary of Manitoba Findings

Problems	*Deprivation Conditions and Duration*					
	Sensory 1 week	Percept < 1 week	Percept 1 week	Percept + Exercise	Immob 24 hrs	Immob 1 week
Arithmetic	NS[1]	C>E	C>E	NS	NS	NS[1]
Number sequences	NS[1]	NS	C[3]>E	NS	NS	NS[1]
Analogies	NS[2]	NS	NS	NS	NS	NS
Pattern sequences	NS	C>E	C>E	NS	NS	NS[1]
Designs test	NS	C>E	C>E	NS	NS	C[3]>E
Verbal fluency	NS[1]	C[3]>E	C>E	NS	NS	C[3]>E

[1]Strong trend C > E
[2]Strong trend E > C
[3]Ambulatory controls

of Cohen, Silverman, Bressler, & Shmavonian (1961), after *sitting* in a soundproof chamber for four hours, "showed a decrease in aritbmetical reasoning, ability to abstract and generalize, and reasoning ability."

As can be seen, a week of perceptual deprivation resulted in the most striking SD effects, which were counteracted by physical exercise; less than one week, the next; and a week of immobilization, the next. In the other conditions, no general differences were associated with deprivation. The special nature of the first 24 hours, which was mentioned by the McGill group, showed up again to some extent. In the graphs of Zubek's sensory deprivation and perceptual deprivation articles, it appears that the first day of the session had different effects from subsequent days—although the significance of the Day 1 vs. Days 2–6 differences was not calculated (see graphs in Zubek et al., 1960, 1962).

MEMORY AND LEARNING

I shall now take up work on another type of cognitive behavior, retention and rote learning. On the basis of the dictum of Goldberger and Holt (1958), it would be expected that these kinds of tasks would be but slightly impaired by SD; and, on the whole, this prediction is borne out.

The most frequently used measure in this context has been digit span. The results are quite consistent: no significant decrement as a result of any form of SD (perceptual deprivation: Goldberger & Holt, 1961c; Scott, Bexton, Heron, & Doane, 1959; Zubek et al., 1962; sensory deprivation: Robertson & Wolter, 1963; Zuckerman, Albright, Marks, & Miller, 1962; water immersion: Goldberg, 1961; immobilization: Zubek & Wilgosh, 1963; Zubek et al., 1963; Zubek & MacNeill, 1966). In fact, actual improvements have been found (Goldberger & Holt, 1958; Cohen, Silverman, Bressler, & Shmavonian, 1961; Myers, Murphy, Smith, & Windle, 1962).

Memory for other kinds of stimuli is apparently somewhat more susceptible to impairment as a result of SD. Recall of geometric designs was adversely affected by 8 hours of perceptual deprivation (Rosenzweig & Gardner, 1966). Three or more days of sensory deprivation has been found to have detrimental effects on both immediate recall and recognition of previously learned nonsense syllable lists (Zubek, Sansom, & Prysiazniuk, 1960); less than a week of perceptual deprivation had the same effect on recognition, but a whole week did not (Zubek et al., 1962); and a week—but not a day—of immobilization significantly interfered with recall (Zubek & Wilgosh, 1963; Zubek et al., 1963; Zubek & MacNeill, 1966). In Kokubun's (1965) study, on the other hand, 18 hours of sensory deprivation *facilitated* the retention of two-letter Japanese syllables.

When we consider memory for connected meaningful material, fewer studies are available. According to Kokubun (1965), a day of sensory deprivation did not result in differences between experimental and control

groups on the retention of verbal material The same was true for performance on the Babcock Story Recall Test although more of the perceptually deprived subjects showed improvement than deterioration (Goldberger & Holt 1958) Grissom Suedfeld and Vernon (1962) tested subjects recall immediately after hearing a 182 word passage from *War and Peace,* and retested after 24 hours of either sensory deprivation or normal activity They found that while there was a significant drop in retention for the control group there was none for the experimental subjects The latter in fact showed a nonsignificant reminiscence effect—they remembered more after 24 hours than at first! (The subjects did not expect a retest and only one reported that he had thought about the passage during the interim so that disuse was the same for both groups) No intergroup differences were found in other studies using the same design with shorter intervening periods (Grissom 1966 see Fig 5–1) Grissom (1963) has also found that—contrary to hypotheses derived from consolidation theory—it makes no difference whether the subject is put into SD immediately after or 24 hours after the first test

Several studies have been concerned with the learning of lists of adjectives The first of these (Vernon & Hoffman 1956) was also the first to indicate that SD might have beneficial effects on intellectual performance four subjects who were sensorially deprived for 48 hours each were tested at intervals of 24 hours before during and just prior to the end of confinement again immediately after release and twice more at 24 hour

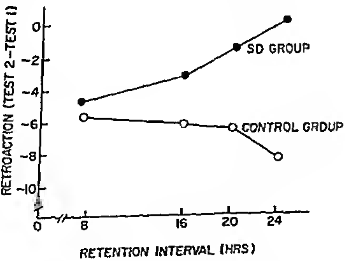


FIGURE 5–1 *Changes in retention as a function of test retest intervals*

SOURCE Modified by permission from R J Grissom unpublished doctoral dissertation, Princeton University 1963

intervals Their ability to learn the 12 item lists by the method of anticipation improved during deprivation (fewer trials to reach the criterion of one errorless trial) while a control group showed no improvement

In an attempt at replication, Vernon and McGill (1957) used 15 adjective lists, 72 hours of deprivation, and nine subjects in each group Using trials to criterion or number of errors to criterion as the measure of learning ability, they found no significant differences between the experimental and the control groups However, on the during-deprivation tests, the experimental group made fewer incorrect responses, had fewer fluctuation cycles (correct response followed by an incorrect response) and also had a better efficiency ratio (defined as the number of trials to criterion, plus the number of trials required to get every item correct at least once divided by trials to criterion) The experimental group was also less variable in performance Thus the trend toward improved learning was found again In a technical report, Vernon (1961) discussed additional data bearing on the 1957 study Counting the number of subjects who showed improvements from the first test administration to later ones he found that the facilitation effect was strongest after 24 hours of sensory deprivation (see Table 5–2) The matter of the one-day ' critical period for cognitive effects was thus raised again The minimum time required for cognitive changes to occur may have been identified by Jaffee (1966) who found that 5 minutes of sensory deprivation improved the ability of sixth grade pupils to memorize a word list while 1 minute had no effect

In contrast to the findings discussed above, Arnhoff Leon, and Brownfield (1962) reported no differences of any sort using 15-adjective lists before, during and after 48 hours of perceptual deprivation This and the finding that 2 to 3 days of perceptual deprivation had but little effect on ' associative learning (Scott Bexton Heron & Doane, 1959) might lead one to hypothesize that perceptual deprivation has effects on learning ability which are different from those of sensory deprivation, but the Manitoba group failed to obtain significant intergroup differences in rote learning ability using either 1 to 10 days of sensory deprivation up to a week of perceptual deprivation (although the experimentals showed a

trend toward improvement), or a week of immobilization (Zubek, Sansom, & Prysiazniuk, 1960, Zubek et al, 1962, Zubek & Wilgosh, 1963, Zubek & MacNeill, 1966) For this reason, it is too early to conclude that these different methodologies have significantly different cognitive effects

In summary, the data on the effects of SD on memory are highly suggestive the less meaningful the stimuli, the more consistently do we find decrements The list of stimuli used includes geometrical figures, nonsense syllables, numerals, real syllables and meaningful verbal material, in general, the incidence of memory decrement follows this inverse order

Learning efficiency seems to be either facilitated or unaffected by SD Since only relatively meaningful material has been used in this context, the findings are quite congruent with those on memory, the use of numerals figures, nonsense material, etc, should be encouraged to find out whether the significant variables in these two areas are the same

TESTS OF CREATIVITY AND FREE VERBALIZATION

The last type of cognitive task used by SD researchers measures what Goldberger and Holt (1958) felt would be the most adversely affected aspect of intellectual functioning the active manipulation and generation of ideas There are relatively few studies in this area, most of them using versions of standard projective techniques Again, the reader should remember the orientation of this chapter—it will not be concerned with the clinical or personality interpretation of projective-test performance in SD, but only with the intellectual or formal aspects of the response

Reasonably enough one of the first studies in this group was performed by Goldberger and Holt (1961c, Goldberger, 1966b) 'The subjects were given two cognitive tests designed primarily to tap the subjects ability to deal with a relatively unstructured cognitive task one required the subject to make up two TAT stories from a verbal description of the cards, the other asked the subject to present a 10-minute monologue on a given topic There were no significant differences in 'compliance with the story instructions affective tone, story length [or] amount of non-contributory verbiage This was the LSD placebo-SD study, and differences were found between the LSD and the placebo groups and between the LSD and the perceptual deprivation groups (LSD produced less obedience to instructions shorter stories and more noncontributory material than did the other two treatments), but not between the perceptual deprivation and the placebo groups (the methodology of this experiment is described in more detail on pages 135–136)

Several other studies have used an oral projective technique Spprelle, Long and Lucik (1963) used zero and 45 minutes of sensory deprivation the subjects being seated to measure changes in storytelling The instructions were that (a) the story was to take five minutes, and (b)

the subject the experimenter and two other characters were to be in volved In scoring the stories the investigators found no difference in the percentage of independent clauses within each story which referred to the examiner significantly more references to the subject himself with no mention of the examiner on the part of the SD group and more refer ences to the environment among the control group Further over all pro ductivity dropped significantly from the shorter [i e zero] to the longer period of isolation

Comparable with the last finding was a report by Zuckerman Al bright Marks and Miller (1962) that the mean number of words emitted during a 3 minute free association period dropped when subjects under went perceptual deprivation in an iron lung Lung confined but non deprived and nonisolated subjects showed no change while a nonconfined control group increased its production Only the difference between the experimental and the nonconfined groups was significant

These experiments are to some extent related to the studies of spon taneous verbalization but the finding that SD results in less talking is very clear here What about our previous inference that high output is associated with poor concentration and that cognitive efficiency improves as one adapts to SD ? One possibility is that since the verbalization in the studies currently being considered is relatively goal-directed the subject cannot evidence impaired concentration by talking a lot but skipping from topic to topic if he has to stick to one topic but finds it difficult to concentrate he is likely to say less This should be evident if he is in structed both to stick to one subject *and* to speak as much as possible

This was the case in two studies by Suedfeld and co-workers (Sued feld Grissom & Vernon 1964 Suedfeld Vernon Stubbs & Karlins 1965) and the findings supported the hypothesis stated above Brief scenes were described orally and subjects were told to make up stories based on these scenes They were to identify each of the three characters and describe the antecedent events current developments and future outcome of the scene The instructions clearly emphasized the desirability of detail and elaborateness—and consequently maximal length—in the stories Thus instructions reinforced the hypothesized desire to maintain social contact and to test the differences between the motivational effects of isolation plus instructions and the cognitive effects of sensory deprivation an isolated non SD group was included in the design

The first study demonstrated that a 24 hour sensorially deprived group significantly decreased the lengths of its stories (by over one third in fact) the isolated group increased its story length (by three fifths) and there was essentially no change in the nondeprived nonconfined and nonisolated control group (Note incidentally that the counterpart of this control group used by Zuckerman Albright Marks and Miller showed a significant increase in production *during a 3 minute period*—

i e they spoke faster than before The essential difference between the studies was that Zuckerman et al had no indication of how long the sub jects would have continued to talk and of course did not indicate to the subjects that they were supposed to talk a lot) Like Zuckerman et al s experimentals Suedfeld s also spoke significantly more slowly after ex periencing SD his other two groups also showed a drop in speech rate but not a significant drop Compatible with this we have the report of Walters and Henning (1962) that *isolation without SD results in decreased speech rate* 6 hours of isolation more so than 3

In the 1964 study there were preliminary intergroup differences of such a nature that the results could have been ascribed to regression toward the mean In the second study therefore the groups were matched on the lengths of their first (pretreatment) stories (Suedfeld Vernon Stubbs and Karlins 1965) The story length results were replicated after the 24 hour SD isolation or control treatment Each subject was then given a week off after which the treatment was repeated As expected adaptation had taken place *no group showed a significant change in story length the second time* One interesting sidelight was that a four man subgroup in the isolation-only condition underwent the first session in uncomfortable heat This group decreased the length of its stories as had the SD group but unlike the rest of the isolation group on the sec ond administration of the treatment at normal temperature these sub jects showed an increase in story length In other words heat added to isolation (like SD added to isolation) overcame the tendency generated by isolation *per se* and under these combined conditions no adaptation to social isolation itself took place

Oyamada and Sato (1965) presented their subjects with TAT like cards and found that both latency in beginning to respond and the temporal duration of the response were less for a 24 hour sensorially de prived group than for controls The investigators concluded that subjects are made to accelerate their verbal response as a result of sensory depriva tion Such a consideration is not incompatible with what was reported before Actually as we have just seen it is not very compatible both Zuckerman Albright Marks and Miller (1962) and Suedfeld Gris som and Vernon (1964) had found decreased speech rate among SD subjects In fact Sato and Ohyama in a previous study (1963) had reported that deprived subjects had longer reaction times on the Rorschach while the durations of the responses themselves were about equal The experi mental group gave a larger number of responses in that study so that one might argue that they were speakiog faster It seems obvious that one cannot say much about speech rate on the basis of response durations it would be crucial to obtain a measure of the amount of output as well It remains to be seen whether the differences between the two Japanese studies are due to differences between the tests as the authors hypothesize

(the Rorschach providing a completely unstructured stimulus thus mak ing it harder to organize the cognitive field) The differences between their findings and those of the American experimenters may be affected by this same factor as well as by procedural inconsistencies (e g differences between oral and visual TAT stimuli the interruptions of the SD situa tion in the various modalities) and possibly by cultural factors After all Princeton and Manitoba students unlike almost any others seem con genitally reluctant to experience visual hallucinations while in SD—and cultural differences between Princeton and Adephi or between Manitoba and McGill are much less striking than those between Japan and the United States

Content analysis of the stories told by the subjects in the Suedfeld experiments was disappointing Scoring for cognitive variables novelty of production and need for novelty (Maddi Charlens Maddi & Smith 1962 Maddi & Berne 1964) revealed no intergroup differences This was con gruent with the findings of Robertson and Browning (1963) that there were no differences between 3 hour sensorially deprived subjects and a control group on several measures of word association performance in cluding one which is related to novelty of production (the number of popular responses) the other measures were reaction time errors in recall and reactions to traumatic words Robertson and Browning had expected to find less common responses after SD basing this hypothesis on the psychoanalytic description of the emergence of primary process under SD conditions (Rapaport 1958)

Zuckerman Albright Marks and Miller (1962) in agreement with Robertson and Browning (1963) wrote of small and insignificant in creases in popular associations for an experimental and two control groups Rosenzweig and Gardner (1966) report that of 20 subjects completing 8 hours of perceptual deprivation (ten with white noise and ten with pat terned but meaningless sound) 15 showed a decrement in popular re sponses on the Holtzman Inkblots In contrast of ten subjects who were given visual perceptual deprivation but with tapes containing stories playlets etc. instead of either unpatterned or meaningless noise only four showed decrements Four of the ten showed increments as compared to none of the 20 control subjects! According to Myers Murphy Smith & Goffard (1966) deprived subjects showed decreased associational produc tivity on a written but not on an oral test—possibly a motor rather than a cognitive effect This finding is difficult to interpret since popular responses may be indications either of efficient (systematic or logical) or inefficient (stimulus-bound or unoriginal) cognition More detailed analyses of the specific responses are needed to tell whether the data reflect improved or deteriorated performance

Ohkubo (1963) reported that word association responses showed less complex behavior in a deprived than in a control group being character

ized by more grammatical contrast responses (and by fewer such responses than were given by a time pressure group which had to respond within six seconds) Goldberger and Holt (1958) preceded the administration of a word association test by giving 8 hour isolated subjects an auditory vigilance task to test the hypothesis that the steady focusing of attention on a monotonous task will impair secondary process thinking There was considerable stimulus bound thinking reported—not the free flow we would expect from primary process The word association test confirmed that there was a general narrowing of the cognitive field by the stimulus boundedness of subjects thought —again a low level of cognitive complexity In general research on the effects of SD on originality of production is inconclusive although there appears to be a trend toward less original output

Suedfeld and Vernon (1965) put together the findings of several studies to propose a curvilinear relationship between stress and verbal originality In a pilot study they compared the word association responses of seven subjects who quit a sensory deprivation experiment with those of 15 subjects who completed the required 48 hours They found that the early terminators had pre to post session changes toward commonality which were 3½ times as great as those of the stayers In the rest of the study indices of subjective stress were correlated with word associate originality and performance on the Uses Test (Getzels & Jackson 1962) Greater stress was associated with greater originality on 11 of the 12 correlations but significantly so on only one The authors concluded that in monotonous situations at least a U shaped function describes the correlation between stress and changes in verbal originality When the monotonous environment involves little or no stress (as in the study of Maddi Charlens Maddi and Smith 1962) or when it involves high stress (as for the quitters of our pilot study) there is a general decrease in verbal originality At moderate stress levels (Suedfeld Grissom & Vernon 1964 and in the present experiment) the relationship is less clearcut although there may be a tendency towards increased originality as a function of stress

In a study by Murphy (1966) an auditory test was administered to a group of 2 hour perceptually deprived subjects and a group of subjects who were merely isolated for 2 hours The test required the subject to tell stories about ten series of three recorded sounds each—e g police squad car siren footsteps running down stairs airplane in power dive (the actual sound effects were not so clearly identifiable) Pre- and post confinement stories were scored for maturity the score depended upon the degree to which the sounds were differentiated and [stood] in clear relation to one another and to the single unifying theme of the response

[e g] The cops arrive at the scene of a burglary causing the robber to run down the back stairs where he is brought to bay by a police plane

[Note, by the way, that maturity as defined by Murphy is very close to the dimension of cognitive or conceptual complexity—i e , complexity of intellectual functioning See for example, the paragraph-completion scoring system for conceptual complexity (Schroder Driver, & Streufert, 1967)] SD plus explicit suggestion concerning past SD findings (hallucinations, decrements etc) produced significant increments in immaturity scores and decrements in maturity scores in both field independent and field dependent subjects, SD without suggestion produced maturity decrements among field-dependent subjects only, and social isolation without SD had no significant consequences regardless of suggestion or personality In brief, all four SD subgroups showed changes in the expected direction, three of them significantly

In one last study, Suedfeld Glucksberg and Vernon (1967) had subjects attempt to solve Duncker s (1945) candle problem after 24 hours of sensory deprivation This problem requires some exploration of alternatives and some ingenuity in devising a method for fastening a burning candle to an upright cardboard wall The over all comparison between the deprived and the nondeprived groups showed no significant difference. However when other independent variables were added, there was support for an expanded version of the U-curve hypothesis stated above—a version in which the underlying construct is activation or arousal in general rather than stress in particular A more complete discussion of this experiment will be given in the next section

GENERAL CONSIDERATIONS

We can be fairly confident in some conclusions about the effects of SD on experimenter initiated cognitive performance For one thing there seem to be no striking differences among the consequences of the various SD methodologies although perceptual deprivation may result in deficits slightly more reliably than does sensory deprivation on the same problems (see also Schultz, 1965) Varying deprivation durations do not seem to make much difference either with the exception that 24 hours often shows up as a demarcation area—whatever phenomena will appear have usually appeared by then and further confinement frequently results in adaptation The timing and the conditions of testing are important effects are geratest when the test is given during SD (i e prior to release) and under SD conditions The administration of long test batteries may dispel the consequences of SD analysis of order effects is required (but has never been performed) to test this possibility

It can be agreed that repeated confinement results in adaptation (Ruff Levy & Thaler, 1961, Pollard, Uhr & Jackson 1963a Suedfeld Vernon Stubbs & Karlins 1965) in fact Zubek et al (1962) showed that previous experience in sensory deprivation reduces the effects of perceptual deprivation employed a year later[1] Unfortunately there have not

been enough such cross-methodological studies Required physical exercise (Zubek 1963a, see also Courtney, Davis & Solomon, 1961) also reduces SD effects which is reasonable in view of the fact that immobilization can produce them (Zubek & Wilgosh 1963, Zubek & MacNeill, 1966) The differences between various amounts of *permitted* movement in an SD chamber seem to be negligible

The data in Table 5–3 point out another, and probably critical, variable In the table tasks are arranged in order of complexity—from memory, which requires the least amount of active intellectual performance, to open ended creative thinking which demands the most While the finer distinctions within each category are difficult to make and no doubt disputable, they have been made as logically as possible (Problems are not always labeled as the original authors labeled them, and some of the reports whose tasks or results could not be trichotomized have been omitted)

By task complexity, I don t refer merely to difficulty, these are probably orthogonal variables Adding two 15-digit numbers is appreciably more difficult, but little more complex, than adding two 3-digit numbers Rather, reference is to Goldberger and Holt s (1958) ' active reflection and manipulation of ideas, and to Bartlett s (1958) open system rather than closed system thinking To the extent that the solution of a problem depends on the use of overlearned, structured, logical steps to reach a definite, clear answer, we have a simple or closed system task, to the degree that new combinations must be made, uncertain approaches tried, new material generated, on the way to an unknown, self-defined, unstructured goal the problem lies on the complex or open system half of the complexity continuum (Note that it *is* a continuum—not a dichotomy!) While degree of complexity is obviously difficult to measure, in general an ordinal scale can be identified

Parenthetically, it is probably here that those researchers who abandoned Goldberger and Holt s proposition went astray The Watson Glaser Critical Deductions subtest is not open-ended, neither are other tests of numerical or logical reasoning Schultz (1965) makes this error when he says, 'It has been noted that the complex ability of verbal reasoning was not impaired whereas the simple task of verbal fluency was impaired " By the criteria just proposed verbal fluency is a more complex task than verbal reasoning and the Goldberger and Holt formula stands Table 5–3 clearly shows the positive relationship between problem complexity and performance deterioration in SD note, incidentally, that it is only on the most complex tasks that more than half the studies obtained significant SD effects Figure 5–2 summarizes the data presented in Table 5–3

The arousal U-curve is one of the two most important factors which determine the effects of SD on cognitive performance, the other being

TABLE 5.3 The Effects of SD on Tasks Varying in Complexity (Summary of the Literature)

Task	*Number of Studies Indicating*		
	Improvement	No Effect	Impairment
A *Simple*			
1 Memory for			
Connected verbal material	2	1	0
Real syllables	1	0	0
Numerals	3	8	0
Figures	0	0	1
Nonsense syllables	0	0	3
2 Learning	3	5	0
Summary	9(33%)	14(52%)	4(15%)
B *Moderate*			
Arithmetic	0	12	5
Number series	0	6	2
Anagrams	0	2	2
Logical reasoning	0	3	2
Candle problem	0	1	0
Analogies	0	7	0
Rhymes	0	3	0
Summary	0(0%)	34(76%)	11(24%)
C *Complex*			
Verbal fluency (restricted)	0	2	3
Visual TAT	1	0	0
Oral TAT	0	2	4
Visual Rorschach	0	0	1
Word association	0	3	2
Uses test	0	1	0
Free association	0	0	1
Summary	1(5%)	8(40%)	11(55%)
D All tasks	10(11%)	56(61%)	26(28%)

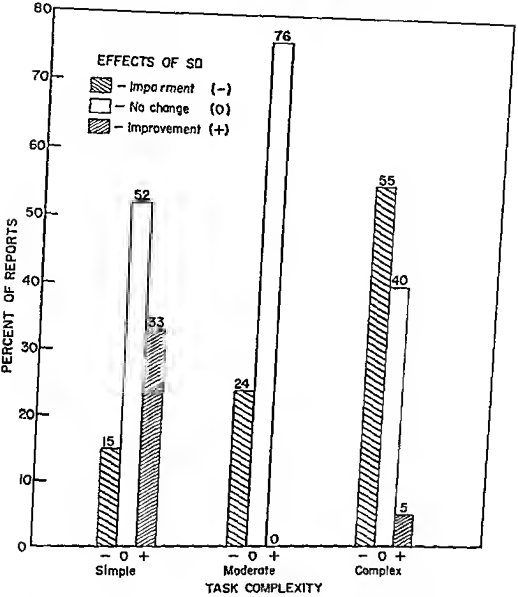


FIGURE 5–2 Changes in cognit ve performance as a funct on of SD and task complexity

task complexity If we hypothesize that the U curve describes the maxi mally complex behavior of which a subject is capable at a given level of arousal we can see that poor performance will result when a task calls for complexity higher than the maximum possible in the current arousal con dition of the subject (cf Yerkes & Dodson 1908 Hebb 1955 etc)

There are intertask differences in the effects of arousal change on performance In general performance on simple tasks is less affected by a change in arousal level than performance on complex tasks There are

also differences in optimal level of arousal it has been hypothesized that optimal level is higher for simple problems (Suedfeld Glucksberg & Vernon 1967) If these hypotheses are correct then Fig 5-3 illustrates the relationships involved in the capacity to perform tasks of varying complexity at given drive levels If we now assume as most activation/arousal theorists do that the normal environment is associated with low moderate arousal and further as SD research has indicated (see chapter 8 of this volume and Suedfeld 1966) that SD increases arousal level we can explain the inconsistent cognitive effects of SD Starting at point A which we shall call normal arousal and going to B—which represents arousal level in SD—we see the improvement which has been reported for simple problems and the deterioration of complex task performances

SD then is a drive inducing treatment the drive being need for stimulation and/or for information (see Lilly 1956 Jones Wilkinson & Braden 1961 Goldstein 1965) This explains why movement or the introduction of meaningful stimuli (Rosenzweig & Gardner 1966) reduces its effects It also accounts for the fact that in general there is more deterioration on tests given during or just before the end of SD in SD conditions than on tests given after—even immediately after—the end of the session (when drive level has already been reduced somewhat by the end-of session procedure itself)

If we extend the arousal range either by adding other drive manipulations (Suedfeld Glucksberg & Vernon 1967) or by looking at individual differences (Suedfeld & Vernon 1965) we can of course observe effects on both slopes of the U-curve More studies of this sort could test the hypothetical functions drawn in Figure 5-3

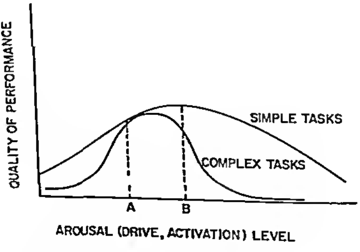


FIGURE 5-3 Arousal task complexity and cognitive performance

Let us return for a moment to the study (Suedfeld Glucksberg & Vernon 1967) which was mentioned at the end of the previous section It may be recalled that Duncker s candle problem was used The subject is given a candle a vertical slab of cardboard and a number of common household objects including matches and a small box of thumbtacks His task is to affix the candle to the cardboard wall so that it stays there and burns Besides SD (incidentally the subjects were blindfolded and were still in the SD chamber) two other independent variables were used —competition for a financial reward and response competition The reward was manipulated by offering one group 5 dollars or 20 dollars if their performances were in the fastest 25 percent or the fastest respec tively another group was offered no such incentive The second variable was manipulated in the following way the correct solution to the problem is to use as a candle holder the box which contains the tacks When the problem is presented with the box and the tacks separate the correct solution is high in the response repertoire and there is little response competition when the box is presented full of tacks competition is high (Glucksberg 1962)

The study thus used four levels of motivation—deprivation plus financial incentive deprivation without incentive incentive without deprivation and neither deprivation nor incentive—in two response com petition conditions It was found that 24 hours of sensory deprivation and the financial incentive had similar results the performances of the SD no incentive and of the nonconfined high incentive groups were both better than those of the nonconfined no SD group Thus moderate drive arousal led to better performance than low arousal When the high arousal group was added (SD plus incentive) the U curve emerged performance became poorer than in the two moderate groups (see Fig 5–4) In other words efficiency was now over the optimum hump and on the downturn Re sponse competition was a significant main effect with the high response competition subjects doing worse the arousal manipulation had similar effects in both competition conditions but the effect was not significant under low competition This may imply one reason why some perfor mances are not affected very much by SD they may be so simple that the amount of arousal change induced by the experimental situation is not sufficiently large to affect them

This is a very general and vague first step at defining the relation ships involved Obviously many other variables must also be considered and the ones described here must be investigated in depth The exact amount of arousal change brought about by a given SD treatment is clearly reduced by meaningful input by required exercise and by adapta tion and it must also be affected by instructions and expectations which bear on drive level—e g anxiety arousing instructions (Orne & Scheibe 1964 Dohrenwend & Dohrenwend 19(6)—by confinement duration by

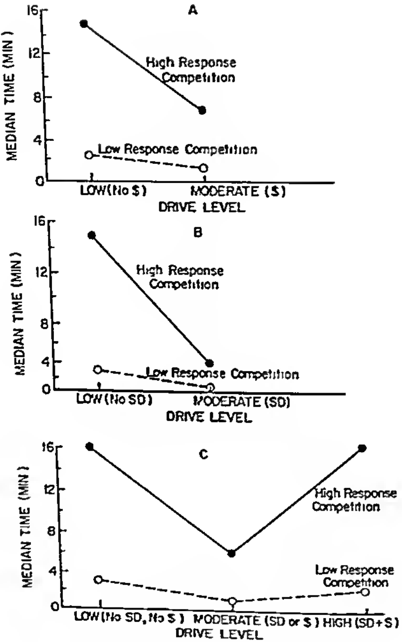


FIGURE 5–4 Solution time for the candle problems as a function of drive level and response competition (A) effect of financial incentive (no SD) (B) effect of sensory deprivation (no incentive) (C) effect of the combined drive operations

SOURCE Reprinted by permission from P Suedfeld, S Glucksberg, & J Vernon *J exp Psychol* 1967 75 166–169

type of SD employed by personality differences among the subjects etc The effect of a given amount of change depends on the accustomed arousal level of the subject his arousal level immediately prior to and during SD his ability to cope with changes of that particular magnitude and last but not least the exact degree of complexity of the problem

One relevant finding and discussion was that of Myers Murphy Smith and Goffard (1966) on auditory vigilance (number of missed signals and latency of response to a series of 1/10 second tones being used as the dependent variable) The experimental group underwent 72 hours of sensory deprivation one control group was tested in a dark room and one in an illuminated room The findings were as follows

1 A significant vigilance effect [i e decrements] occurred in all groups there *were invariably more slow trials in the second half of the [48 minute] test than* in the first
2 The Cubicle [SD] subjects were uniformly and considerably more vigilant than the Dark Controls
3 The Cubicle subjects and the Light Controls were about equally vigilant on the first half of the test but the Light Controls showed a significantly greater vigilance effect or decrement

The authors conclude that Light Control subjects were normally alert while the Dark Control subjects became increasingly less alert and the Cubicle subjects remained continuously hyper alert In our terms SD led to a higher arousal level more favorable to the performance of this simple task while the Dark Control condition quickly and the Light Control condition gradually took the subjects along the downward slope of the low arousal half of the U-curve

Actually the SD cognition literature is by no means as helter skelter as it appears at first glance Aside from the systematic consequences of the variables already discussed it should be noted that disagreements are generally of the no difference–significant difference sort rather than findings of a significant difference in one direction vs a difference in the opposite direction Given the difficulty of proving the null hypothesis by no difference results the resultant lack of agreement appears considerably less troubling

It is equally obvious however that there remains much to be learned about the functioning of the many variables involved and about the interactions among them To reiterate what I have advocated before (Suedfeld 1964d 1966) I think it is important to attack these problems in a systematic theory-oriented program The Suedfeld Glucksberg and Vernon (1967) study is the first step in one such program but the complexity of the situation and the high level of controversy among researchers would seem to urge the use of as many theoretical and methodological approaches as possible

SUSCEPTIBILITY TO EXTERNAL INFLUENCE

Next, we shall turn to the second major topic of this chapter sug gestibility and persuasibility This is the area which first led the McGill researchers toward the invention of SD As Hebb wrote

> The work that we have done at McGill University began actually with the problem of brainwashing The chief impetus of course was the dismay at the kind of confessions being produced at the Russian Communist trials Brain washing was a term that came a little later applied to Chinese procedures We did not know what the Russian procedures were but it seemed that they were producing some peculiar changes in attitude How? (Hebb 1961, p 6)

The relevance of the SD paradigm to brainwashing (and for that matter, the relevance of brainwashing to Russian confessions) will be taken up in the second part of this section The first part will deal with primary nonattitudinal suggestibility

Primary Suggestibility

Very few studies have been concerned with primary suggestibility as a result of SD Even among these few, there is no complete agreement about the nature of the phenomenon

The first article to mention this factor was that of Vernon and Hoffman (1956) whose four subjects underwent 48 hours of sensory deprivation In a cryptic statement which has frustrated several subsequent reviewers the authors said, Attempts to measure the effect of sensory deprivation on suggestion by the Hull body sway technique, proved un successful A technical report written by Vernon (1961) shed more light on the subject Measuring spontaneous sway and sway with suggestion before and after SD the experimenters obtained the data presented in Table 5-4 This was apparently a later study than that of Vernon and

TABLE 5 4 Sensory Deprivation and Body Sway

Body Sway (mm.)	*Pre SD*	*Post SD*	*Post SD + 48 Hours*
Normal Sway	280	287	249
Suggested Sway	294	338	245
Difference	14	51	−4

SOURCE *Inside the Black Room* by Jack Vernon Ph D copyright 1963 by Jack A Vernon Used by permission of Clarkson N Potter Inc

Hoffman since 72 hours of deprivation were used and Vernon contradicts the earlier report when he says 48 hours was almost as effective as 72 hours At any rate it is clear that deprivation increased body sway suggestibility in this later study (This experiment is also discussed in Vernon 1963)

The same phenomenon was found by Jones and Goodson (1959) who had 24 naval aviation cadets sitting in a 2 × 3 booth with blank walls and a humming air conditioner for approximately eight hours each At the end of this period experimental subjects were more suggestible than controls as far as body sway was concerned falling faster and more frequently On arm levitation and leg catalepsy although there were differences in the same direction they were not significant Levitt Brady Ottinger and Hinesley (1962) indicate that three student nurses who failed to follow hypnotic eyelid catalepsy suggestions still failed to do so when these suggestions were repeated after 4 hours of sitting in a perceptual deprivation chamber

The only definitely negative body sway result was that of Walters Callagan and Newman (1963) Strictly speaking this study does not belong in this chapter because it used only social isolation and not SD To demonstrate that isolation by itself does not produce increased suggestibility we have the report that 20 federal prisoners voluntarily isolated for 4 days each showed no such change Apparently theories of social drive are inadequate to explain the SD results (although as Walters and his coworkers pointed out long term dormitory living federal prisoners are a socially satiated group whose social drives may not be reactivated by a mere 4 days of being alone) An information processing or judgmental anchor model would be preferable the lack of guidelines as to what is the right thing to do in SD increases the subject s receptiveness to prestige suggestion

Two SD studies investigated suggestibility in the perceptual rather than the motor dimension Walters and Quinn (1960) gave their subjects 30 minutes each of either sensory deprivation (blindfold and earplugs) social isolation both or neither The deprivation plus isolation group showed the smallest latency and the greatest suggestibility on the autokinetic effect It may be noted that sleep deprivation also increases autokinetic suggestibility (Fisher & Rubinstein 1956) while social isolation does not (Walters Marshall & Shooter 1960)

These last authors found that an hour of isolation did not make any difference in the autokinetic suggestibility of adolescent boys Anxiety arousing instructions concerning a preceding testing session however led to increased suggestibility The authors reinterpret a previous report (Walters & Quinn 1960) that isolated subjects showed smaller autokinetic latencies in terms of two factors (1) the effects of SD on a subgroup which

had both SD and isolation, in that SD affects the perceptual world of the subject; and (2) anxiety aroused in the isolated-non SD group. Then they hypothesize that "it is probably . . . the arousal of anxiety that accounts for some of the puzzling consequences of sensory deprivation." They should probably have left it at "arousal," since neither the range nor the level of anxiety aroused in the majority of SD subjects is likely to be great enough to account for all that puzzlement (see, e.g., Myers, Murphy, Smith, & Goffard, 1966).

The second study was conducted by Vernon (1961). A series of geometrical figures was shown at 1/100 of a second per stimulus, and the just-released subject was asked to draw each figure as soon as he had seen it. The experimenters slyly introduced circles with successively larger gaps in them, expecting that "the suggestion of the other closed figures would cause the SD subjects to detect the gaps in the circles only after they had become quite large." The researchers were disappointed—SD subjects saw and drew the gaps just as soon as the controls did. But in one of the more enjoyable switches in the literature, they demonstrated suggestibility anyway; they began to draw the other figures with gaps, too! Of the 85 noncircle figures, which were always presented closed, they drew an average of 23 open; the control group *never* did this.

Besides these studies, the reader might look at the extensive literature on the effects of suggestion on reports of visual imagery during SD. While there is a great deal of controversy, we can say at the very least that in numerous experiments "SD phenomena" have been attributed not to SD itself, but to suggestion and/or expectation. The role of *increased* suggestibility as a result of SD has not been investigated specifically in this context, but it should be. (See chapter 3 for a review of this literature.)

Although there have not been too many relevant experiments, I think we can agree that the evidence is fairly strong. SD does seem to increase suggestibility both in the perceptual and in the motor aspects of behavior. It is now time to look at secondary suggestibility, or persuasibility, and its relationship to SD.

Persuasibility

The similarity between brainwashing and SD is a tenuous one. First of all, the method of brainwashing most frequently used by the Communists in China depends upon over- rather than under-stimulation (e.g., Lifton, 1961; Schein, 1961). Lack of sleep, lack of privacy, hard labor, and constant heckling and arguing are just the opposite of what the SD subject experiences. It has been argued by several writers, including myself (among others, Hebb, 1955; Malmo, 1959; Easterbrook, 1959; Lindsley, 1961; Fiske & Maddi, 1961b; Suedfeld, 1963), that the effects of suboptimal and superoptimal stimulation are similar; still, it would seem more rea-

sonable to use a technique with some amount of face validity in the study of Chinese brainwashing SD certainly does not possess that attribute

On the other hand it is documented that the Soviet version of brain washing depends greatly on isolation and monotony (e g Krivitsky 1939 Weissberg 1951 Rogge 1959) It is also true that some use of isolation by the Chinese has been reported (Hinkle & Wolff 1956 Schein 1960) but its most well known application was in the Moscow Purge Trials of the 1930s and the post World War II purges of Eastern Europe

Aside from the methodological differences the objectives of Chinese and Russian thought reform (the correct translation of the Chinese term) are also widely disparate In fact the Russians aimed not at conversion but at confession The confessed criminal was not released into the community to go and sin no more as with most Chinese graduates of the process rather he was executed Thus only a brief period of compliance was required of him Aside from the mystical (I am tempted to say mythical) brainwashing technique the persuaders used the old Bolsheviks loyalty to the Party (cf Koestler 1946) as well as actual and threatened physical torture (Rogge 1959) to accomplish their ends The resemblance of this approach to persuasion is pretty remote

Indeed two more comments about the myth of brainwashing are relevant here First it is by no means as infallible as popular journalism has painted it In the Purge Trials in the East European trials after World War II and in the Chinese prisons and revolutionary colleges a great number of people never submitted of those who did a majority recanted as soon as it seemed safe to do so As far as the brainwashing of American prisoners during the Korean War is concerned it occurred very rarely indeed and succeeded even more rarely (see e g Biderman 1963) Second its supposedly unique nature as a product of Communism *per se* of Pavlovian conditioning, etc is fictional both the Russian and the Chinese versions are direct logical and congruent descendants of age-old police penal and legal methods in those countries Solitary confinement of course is a standard technique in a tremendous number of police/penal systems including the American The reader might want to look at a report concerning one type of prison which was supposed to be unusually efficient at rehabilitating its victims the Philadelphia solitary prison (Dickens 1907 orig publ 1843)

Bearing in mind that it is less than optimal to use SD if one wishes to study *brainwashing* let us now examine the experimental evidence concerning the effects of SD on *persuasibility*

Changes in the Self Concept Following External Influence

A series of studies conducted by Henry B Adams and his co-workers at the Richmond (Virginia) VA Hospital attempted to bring about changes

in the self concepts of psychiatric patients Subjects were placed in a no-vision humming sound combination of sensory and perceptual isolation lying on a bed for up to 6 hours Social isolation was only partial the experimenter was in the same room but did not communicate with the subject (who did however know of his presence) The practice of presenting tape recorded messages aimed at strengthening the self-concept was introduced when the experimenters realized that the stimulus hunger of the sensorially deprived patient might make him more receptive to such input (Adams 1964 see also Gibby Adams & Carrera 1960 Cooper Adams & Cohen 1965)

After 4 hours of deprivation Gibby and Adams (1961) played a 14 minute tape stressing that (1) the subject did not view himself as a worthwhile person (2) there was a discrepancy between the way he saw himself and the way he was actually seen by others and (3) that he was more acceptable to others and personally more likeable than he himself realized On the Brownfain Self Rating Inventory the deprived group who had heard the message rated themselves much more favorably after the session the change in this group being significantly greater than in three control groups The latter one of which had had SD but no message, one the message but no SD and one neither did not differ among themselves

Adams Robertson and Cooper (1963) used the same technique but had taped messages individually designed for each subject The messages were prepared on the basis of the subject s profile scores on the MMPI and the Leary Interpersonal Check List. Group I heard the message after 2 hours of deprivation and was released an hour later Group II got only the 3 hours of deprivation Group III was a nontreated control

On the Dominance dimension of the Leary Check List Group I (SD message) showed no change for the self-description and decreased the dominance of the ideal person The SD only group (II) increased its evaluation of its own dominance with no change for the ideal the controls (Group III) decreased self-description dominance while raising ideal dominance There were no changes on the self-description nor the ideal on the Love Hostility dimension On the MMPI both SD groups increased on Ma (Group III decreased) showing increased energy and activity as a result of SD On the K scale Group I went down indicating a decrease in defensiveness while the other groups went up significantly Group I also dropped on 9 of the 10 clinical scales a statistically significant phenomenon which did not occur in the other two groups (although the SD only subjects reported less depression more mental activity and alertness[!] an increased tendency to describe themselves in favorable terms and enhanced dominance and ego strength) Thus the SD message group showed the most general improvement on the MMPI with the SD only group demonstrating some improvement Unfortunately this particular

study in the series did not include a message only condition (Robertson 1965 who did include such a condition failed to replicate the findings of Adams and his co-workers)

One statement made by Adams is particularly relevant to our major concern We have exposed a number of non psychiatric subjects to the same conditions as those reported in this study Relatively little personality change was observed The more severely disturbed the [psychiatric] patient was prior to deprivation the more he changed in a favorable direction afterward (1963) This comment supports a report by Henrichs (1963) He gave the MMPI and the Brownfain Self Rating immediately before immediately after and again 20 to 48 hours after a 5 hour sensory deprivation session He used four groups of 10 students each SD plus tape (same message as that used by the Richmond group) SD only message only and neither The two message groups were better than the no-message groups on the final social self rating (e g rate yourself as others see you) the two SD groups were lower than the two control groups on the final private self (as you really are) Apparently SD did not increase the persuasibility of normal subjects about their own personalities

The relevance of these findings to brainwashing may be greater than the relevance of the straight attitude change experiments which will be covered in the next section As has repeatedly been pointed out (Lifton 1961 Schein 1961 Suedfeld 1963) brainwashing in both China and the USSR was in its innermost essence an attempt to change the victim s self concept The Old Bolshevik who had thought that he was trying to save the Communist ideal from Stalin s perversions was persuaded that he was really a saboteur and traitor the missionary who had always seen himself as a self-denying altruistic person was pressured to realize that he was actually a spy a fifth columnist for foreign interests and the business man or student who had always been apolitical was taught that to be apolitical was to be an enemy of the people There were only two categories of human beings oppressed and oppressors if you could not demonstrate that you had belonged to the first you had to be convinced that you must have belonged to the second

This is a change much deeper and more central than attitude change as defined in the usual experiment in social psychology The fact that psychiatric patients but not normal subjects showed this kind of change as a result of propaganda received during SD may mean one of two things (1) for brainwashing to succeed the victim must first be driven into an abnormal state (cf Sedman 1961)—which probably was accomplished by the physical deprivation constant harassment doubt anxiety etc which were chronic factors in the lives of prisoners (Hinkle & Wolff 1956 Farber Harlow & West 1957) or (2) the self-concepts of normal people can be changed by an intensive attack but only in the negative direction Given the ethical codes of Western experimenters neither of these hy

potheses is researchable in any palatable way For the moment, let us be content to note that SD does enhance the impact of therapeutic messages on psychiatric patients

Attitude Change

Like so much else, the study of attitude change in the traditional sense was first coupled to SD at McGill (Bexton, 1953) In the first experiment, one group of subjects heard inane messages before being put into perceptual deprivation These stimuli consisted of (1) eight repetitions of the chorus of 'Home on the Range , (2) two talks for children taken from a Catholic primer, (3) radio soap commercials, and (4) part of a stock market report All members of the group rated these as strongly aversive, yet two of the four subjects asked to hear the records a total of nine times during the confinement session Requests for the stimuli came three times as often during the last half of the session as during the first

Of a group which had not heard the records before entering the chamber three subjects asked for them again after the first presentation during SD, for a total of *53* repetitions! This group unlike the other, reported that hearing the stimuli helped them to tolerate deprivation This study was concerned with 'attitude change only to the degree that eating a normally disliked food when one is particularly hungry constitutes attitude change It did demonstrate for the first time the strength of stimulus hunger in SD, and led logically into the next experiment

The second part of Bexton's (1953) dissertation was also discussed in Scott, Bexton Heron, & Doane (1959) From a student population which was generally mildly skeptical about psychic phenomena—ghosts poltergeists and ESP—14 subjects constituted the perceptual deprivation group During the experimental session they heard a series of nine records presenting strong one sided arguments favoring belief and research in such phenomena, citing authorities and scientific proofs and making *ad hominem* attacks against scoffers Of the 14 experimental subjects 9 asked to hear the records more than once, compared to only 2 of the 17 controls (who were paid extra if they requested repetitions)

On a postsession questionnaire, both groups indicated significant persuasion effects they expressed more belief in the realness of psychic phenomena thought the question was more important and were more interested in the topic The change was significantly greater in the experimental group who also evaluated the records themselves more favorably than did the controls There was no reliable relationship between the degree of change and the number of repetitions of the propaganda This was the first demonstration of increased susceptibility to persuasive messages as a consequence of SD

Myers Murphy, & Smith (1963) systematized this approach by designing two messages of equivalent persuasiveness one criticizing and one

praising the Turkish nation They then selected subjects who had strong attitudes towards the Turks and tried to change these attitudes by presenting the dissonant message Subjects were given 75 minutes during which they could hear one particular 3 minute tape at will

Forty-eight hour sensory deprivation subjects requested the propaganda significantly more frequently than did controls (an interesting datum since people are supposed to avoid strongly dissonant information) but showed no greater attitude change There was however a borderline interaction between treatment and intelligence the less intelligent (though still above the Army's 60th percentile) experimental subjects changed more than the less intelligent controls while the situation was reversed between the two *higher* intelligence groups

As the researchers pointed out this may have been an effect of transparency with the high intelligence experimentals resentful of so massive and obvious an attempt at manipulation Of course preselecting subjects with strong opinions also made it less likely that they would submit if they recognized a blatant one-sided propaganda message

Adopting—and adapting—the HumRRO approach Suedfeld (1963 1964b) combined the two Turk tapes but appreciably weakened the unfavorable message Originally neutral subjects heard the message once only before taking another attitude test One group received the second test just before the end of a 24 hour sensory deprivation session the other after 24 hours of normal activity In this study original attitudes were neutral the message had both positive and negative information so it *seemed* fair and the manipulative attempt was disguised by instructions to try to memorize the material in preparation for a recall test

These subtleties had the desired effect SD subjects evidenced significantly more change in the pro-Turk direction than controls (about eight times as much in fact) and also evaluated the propaganda material more favorably (Suedfeld 1963) Furthermore subjects who had previously been classified as conceptually simple changed more than conceptually complex people in both conditions This personality dimension runs from rigid hierarchical roughly differentiated externally determined information processing at the simple end to flexible combinatorial finely differentiated and internally controlled processing at the complex end (Harvey Hunt & Schroder 1961 Schroder Driver & Streufert 1967) As predicted simple subjects responded to—and accepted—the stronger part of the message while complex ones weighed and combined both arguments arriving at a more balanced opinion This finding is well in line with the performance of simple and complex groups in person perception and other experimental situations (see Schroder Driver & Streufert 1967)

A follow up study (Suedfeld & Vernon 1966) added another refinement The same message was divided into seven combined pro- and anti Turk statements one short statement being presented at a time The

subjects were told that this was a test of comprehension. After hearing each passage, they were asked to evaluate its content (*not* their own opinions) on a number of scales. If their interpretation was that the passage was pro-Turkish, the experimenters presented the next passage; if not, the questions were repeated at 10-minute intervals until the subjects did comply (see Fig. 5–5). After every passage had been heard and evaluated, an attitude scale was presented.

This procedure was based on a proposition advanced by Vernon (1963): producing attitude change during SD by reinforcing each compliant act by "a little light . . . a novel food item . . . social contacts" (cf. some of the methods used by the Chinese, rewarding each small act of collaboration and building up to more and more serious submissions—Schein, 1961). We felt that information need plus stimulus need might make the receiving of new messages an even stronger, as well as a more subtle, reinforcer than purely physical stimulation. It was also interesting to see how this technique would compare with those of Bexton (1953) and of Myers, Murphy, & Smith (1963), whose subjects were given the same information over and over.

It turned out that 24 hours of sensory deprivation increased compliance: that is, the confined subjects gave significantly fewer "neutral or anti-Turk" evaluations of the messages. There was also an interaction with conceptual complexity—in SD, complex subjects were particularly compliant. Given the high information motivation of conceptually complex individuals, this was a predicted outcome.

Attitude change, however, followed a different course. Simple subjects changed in the pro-Turk direction significantly more, just as they had in the earlier study; but there was a significant interaction. While simple subjects changed more in the SD than in the control condition, the

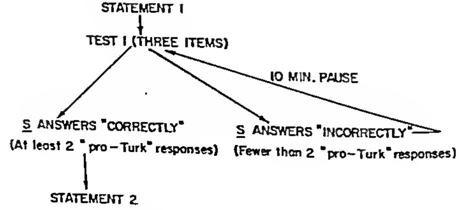


FIGURE 5–5. Presentation of propaganda as a reward for compliance.

SOURCE: Reprinted by permission from P. Suedfeld & J. Vernon, *J. person. soc. Psychol.*, 1966, 3, 586–589.

opposite was the case among complex subjects The latter were apparently able to tolerate the dissonance which was aroused when they rated essentially neutral stimuli as being completely positive, bowing to *force majeure* in order to receive the reward the former could not and had to bring their attitudes into line with their previous compliant behavior (cf Festinger, 1957, Schein, 1961) It is also possible that the complex subjects recognized and reacted against the manipulative attempt, as had Myers, Murphy, and Smith s (1963) more intelligent group (the correlation between conceptual complexity and intelligence ranges from the 0 20s to the 0 50s) Note, incidentally, that in neither Suedfeld study was there a significant difference between the persuasibility of the simple and the complex control groups in both studies there was such a difference between the two SD groups *with simple subjects exhibiting greater attitude change*

Somewhat more ambitiously Patrick (1965) tried to persuade psychotic patients not to smoke by showing them an antismoking film One group saw the movie after an hour of perceptual deprivation Subjects who saw the film smoked *less* during a subsequent 3-hour social isolation session than did no film subjects but the SD treatment made no difference Nor was there a difference in the retention of the material presented in the film, a finding which agrees with that of Suedfeld (1963) concerning memory for the pro- and anti Turk propaganda material The brief period of deprivation and the presentation of propaganda in the visual modality, after release from SD (unique in this portion of the literature) probably explain the lack of positive findings

Two HumRRO studies can be characterized as variants of the original Myers Murphy, and Smith (1963) attitude change experiment Smith Myers and Murphy (1963) used a version of the Crutchfield (1954) apparatus to measure conformity to a fictitious group norm Each of the 39 experimentals and 40 control subjects had to choose the one of three tone patterns which matched a previously presented standard Eighteen such problems were given with the subject hearing the faked answers of three other "judges before and one more after he gave his own responses On six of the 18 problems the bogus group agreed unanimously on a wrong answer

Previous performance on similar problems without group information turned out to be highly related to conformity The 38 percent of all subjects whose original judgments were 100 percent correct averaged only 1 2 conformity errors (agreements with incorrect group choices) while those subjects who had made mistakes on the first test averaged 2 1 conformity errors—a significant difference As has been so frequently hypothesized the group s opinion was one source of information to be used when making a discrimination which the subject found difficult

Discarding the perfect subjects for whom the task was too easy to call for following the group norm the authors analyzed the remaining data They found that SD led to greater conformity among the lower

intelligence half of the group while the conforming behavior of the more intelligent subjects was not affected by deprivation This finding is highly compatible with those discussed before implying personality differences in the magnitude of SD caused disorientation and need for information

Murphy Smith and Myers (1963) used the technique developed by Staats and Staats (1957) to condition connotative meaning Four national groups were used as conditioned stimulus words paired with either positive negative or for two nations neutral adjectives as unconditioned stimuli The valence of the adjectives was measured on the evaluative scale of the semantic differential (Osgood Suci & Tannenbaum 1957) Coupling the specific CS with the specific list of UCS was counterbalanced each nationality being good for one group of subjects and bad for another

Each subject was told to memorize the CS-UCS pairs pronouncing each of them both aloud and to himself He was then given a recall test Next supposedly as part of another experiment he rated national groups (including the critical ones) on several dimensions including three semantic differential evaluative scales

Sixty two subjects were run in each condition SD consisting of 48 hours of sensory deprivation With rank scores there was a significant interaction between intelligence and the experimental treatment just as in the other studies The attitudes of both treatment groups reflected a conditioning effect (although the members of both groups denied any such effect) but it was somewhat larger in the experimental group The presence or absence in a group of people whose original attitudes disagreed with the propaganda was also a significant variable the presence of such people being associated with more change (probably because more change was possible given the nature of the measuring instruments—just as in Myers Murphy and Smith s (1963) Turk propaganda study) Last it was found that control subjects who recognized the true purpose of the study were better conditioned than those who did not This datum is congruent with the literature on verbal conditioning But among SD subjects the reverse was true—realization of the experimenters goal was associated with *lower* conditioning scores! The hypothesis that being manipulated arouses the resistance of SD subjects thus had its most direct confirmation so far On the recall test intelligence was a significant factor but experimental treatment was not repeating the results of the other studies

Further Research

Future research will probably investigate these variables more intensively It would be interesting to see for example whether by changing the reinforcement schedule the Suedfeld and Vernon (1966) technique can be adapted to elicit progressively more intense compliance and attitude change whether some of McGuire s counterpersuasion approaches

would work for SD subjects whether the degree of change can be manipulated gradually by varying the transparency of the propaganda presentation Variations of the SD technique also remain to be explored i e the use of water immersion of social isolation without SD etc

The use of more subject variables would be interesting e g do first born subjects exhibit more suggestibility in SD as they have sometimes been reported to do in normal environments? And if so does SD increase this difference even more? Do these factors have any bearing on the production of SD phenomena by non SD variables such as instructional set? Tolerance for supposedly aversive states may be increased by SD (see Goldstein 1965) does this include cognitive dissonance? If it does what effect does this have on attitude change?

Questions relevant to the U curve hypothesis should also be investigated For example Zuckerman and Haber s (1965) study showed that people who had exhibited high physiological arousal during a 3 hour SD session responded more in order to get visual or auditory stimulation during a second 3 hour session 6 weeks later This finding implies possible relationships between arousal level and such attitude change designs as Suedfeld and Vernon s (1966) As in intellectual performance the degree of structure or uncertainty may also be relevant here Thus subjects with strong preexisting (closed) attitudes such as those in the HumRRO studies are not greatly affected by SD subjects whose original attitudes are neutral (open) are so affected (Suedfeld 1964b Suedfeld & Vernon 1966) The results of Adams and his associates may indicate that the self images of psychiatric patients are less structured and stable than those of normal subjects

Getting away from an overconcern with brainwashing would free the SD researcher to explore these and many more questions on the basis of theoretical and experimental considerations alone

SUMMARY

Research on the cognitive effects of SD demonstrates the importance of the tasks employed Highly structured performances (retention and learning) seem to be undamaged or even facilitated by SD moderately structured ones such as problem solving on standard IQ and other test items reveal some deficit while considerable impairment occurs on unstructured behaviors such as projective test performance Besides this variable perceptual deprivation shows some tendency to produce decrements more consistently than sensory deprivation and immobility increases while required exercise decreases cognitive deficits Adaptation also diminishes the effects with 24 hours of deprivation repeatedly identified as a crucial zone for the beginning of adaptation within one session

(strangely, adaptation takes place on repeated sessions even if each confinement period is less than 24 hours) SD effects are greatly attenuated when the SD condition is disrupted by the availability of meaningful information, whether introduced as an experimental variable, the by product of long test batteries, or the result of testing the subject under non SD conditions

Susceptibility to external influence, including both primary suggestibility and persuasibility, is clearly increased by SD The data indicate that this phenomenon originates with the lack of informational anchors in the SD situation the subject is at loose ends, without guidelines for his behavior, unable to concentrate and in a state of stimulus- and information hunger (He s completely in the dark, in other words) This condition has the effect of maximizing the impact and the reward value of whatever information is made available to him As one would expect, subjects who are less able to generate internal cognitive stimulation and guidelines—i e, those of relatively low intelligence and/or simple conceptual structure—demonstrate these effects more strongly Subjects of higher intelligence or complexity, if they recognize the manipulative intent of the experimental treatment, exhibit resistance and even a boomerang effect

The differential effects of various SD techniques have not been investigated in this context and the comparatively little variation of confinement durations and propaganda presentations makes it impossible to assess reliably the roles of these factors As in cognitive performance, there is some indication that postrelease testing reveals smaller effects than testing during confinement, the persistence of changes induced during SD remains to be established

6

Stimulus-Seeking Behavior

Austin Jones

Underlying most discussions of sensory deprivation phenomena is the assumption that organisms are characterized by a need for variable exteroceptive stimulation and that deprivation of such stimulation is directly responsible for the occurrence of various impairments and distortions of perceptual ideational and affective responses Thus far the sensory deprivation research has been addressed principally to these impairing and distorting effects rather than to the basic motivational assumption which it will be the purpose of this chapter to consider

Among the many writers who have emphasized the importance of the tendency of organisms to seek periodically increasingly variable stimulation Hebb (1955) has been particularly influential within the context of sensory deprivation research Similarly influential have been such theorists as Harlow (1950) and Berlyne (1957) whose studies of curiosity and exploratory behavior have focused upon the nature of the stimuli which are the object of curiosity and exploration rather than as in the case of Hebb and other sensory deprivation theorists upon the deprivation variable and its associated psychopathological phenomena The results of both the sensory deprivation and the exploratory-curiosity experiments have come increasingly to be interpreted as supporting a motivational principle of optimal stimulation (e g Hebb 1955 Leuba 1955 Berlyne 1960 1963 Fiske & Maddi 1961a) According to this principle the organism s behavior is directed to the maintenance of a level of stimulation which is optimal with respect to the responses currently being performed by the organism the level of stimulation being determined by both the intensity and variability of exteroceptive stimulation The various theorists differ considerably in the explicitness with which they consider the relative contribution of intensity and variability to the optimal level of stimulation and it may be questioned whether the two dimensions are appropriately combined to determine a single level of stimulation (Fowler 1965 p 70) In general however somewhat greater weight is typically given to the dimension of variability and Schultz (1965) in his recent review of sensory deprivation research concludes that reductions in stimulus variability result in substantially greater impairment of function than do reductions in absolute stimulus intensity Just what is meant by

stimulus variability is itself of course a fairly troublesome question and one which we will consider in some detail further on

Part of the attraction of the motivational principle of an optimal level of stimulation lay in its relationship to neurophysiological concepts of arousal stemming from the work of Moruzzi and Magoun (1949) Lindsley (1961) and others The ascending reticular activating system (ARAS) is regarded as sampling the total afferent activity and hence, the arousal of the organism and the degree of arousal may in principle be measured by the electrical activation of the areas of the cortex to which the ARAS projects Because of observations that cortical activation and some behavioral measures of activity and alertness were directly related some writers (e g Hebb 1955) have come to consider arousal (degree of ARAS activity) as synonymous with a general drive state (Berlyne also views arousal as essentially equivalent to generalized drive but unlike Hebb considers arousal to be a U shaped function of the level of exteroceptive stimulation) The seeming relationship between the level of stimulation and level of arousal thus suggested to some (e g Hebb 1955 Leuba 1955) that one might speak as meaningfully of an optimal level of arousal as an optimal level of stimulation and consequently that one might describe an organism s behavior as at times tending toward an increase at other times toward a decrease in generalized drive

This latter notion appears to involve an unnecessary and probably incorrect assumption concerning the relationship between level of stimulation and drive as customarily defined in the S R reinforcement theory literature For the purposes of the present discussion the view of drive reduction as reinforcement need not be considered limiting the definition of drive simply to a statement of its energizing function As expressed by Farber for example a variable may be said to constitute a drive variable if the presence of the variable energizes or intensifies whatever reaction tendencies exist in the given situation (1954 p 3) The position of theorists such as Hebb and Leuba who tend to equate the concepts of arousal and drive is based first upon observations that organisms frequently behave in such a way as to increase the variability and/or intensity of stimulation These empirical data appear well established and are not questioned here The second step of the argument is the demonstration that arousal (measured as electrical activation of cortical projections of the ARAS) is directly related to the variability and intensity of exteroceptive stimulation This relationship though not as securely established (Berlyne 1960 for one demurring) also need not be questioned at this point The third and critical step of the argument is the assumption that drive is directly related to the variability and/or intensity of exteroceptive stimulation This relationship employing the behavioral definition of drive given above is empirically testable If it is supported then it would be correct to assert that organisms sometimes behave so as to increase

drive If however it may be shown that such a relationship does not hold that increments in drive may be demonstrated as readily under low levels of variability or intensity of exteroceptive stimulation (and hence under low levels of ARAS arousal) as under high levels then the notion that organisms respond for increases in generalized drive loses its empirical basis It is a premise of this chapter that generalized drive is *not* directly related to level of stimulation (with respect to either variability or intensity) or to level of arousal as measured by cortical activation and that there presently is no basis for the belief that organisms respond for increases in drive as behaviorally defined The evidence from which this premise stems (discussed in detail in a later section) consists of the demonstration of the successively energizing (i e drive) effects of increasing durations of sensory deprivation a condition in which EEG measures show arousal to be *decreased*

PLAN OF THE CHAPTER

The following discussion of stimulus seeking behavior will be organized around the behavioral formulations of drive and incentive phenomena in the belief that certain methodological and theoretical issues will thereby be brought more sharply into focus As a preliminary step the definition of the drive and incentive constructs will be considered with a brief discussion of the requirements for their demonstration in the context of sensory deprivation The empirical research literature will then be reviewed considering first those studies which provided meaningful sensory incentives for which sensorily deprived *Ss* were permitted to respond and second those studies by much the larger group which provided nonmeaningful or content free sensory incentives The following section is devoted to the concept of a homeostatic interpretation of drives associated with the variability of stimulation and the final section deals with the relationship of the animal literature on curiosity and exploratory behavior to the human sensory deprivation literature

REQUIREMENTS FOR THE DEMONSTRATION OF DRIVE AND INCENTIVE PHENOMENA

Drives

As noted above a broad definition of drive as an energizing process will be followed in this discussion A variable may be said to constitute a drive if as expressed by Farber (1951) it energizes or intensifies whatever reaction tendencies exist in the given situation While the demonstration that the prompt reduction in intensity of a variable strengthens the tendency of the preceding instrumental response suggests

strongly that the variable in question functions as a drive, such a demonstration will not be held here as a requirement for the establishment of a drive

The definition of drive as an energizer or intensifier of reaction tendencies is a definition of drive as a theoretical construct in the manner of Hull (1952) and Spence (1956), according to which greater amounts of a variable must lead to correspondingly greater energizing or intensification of reactions in order for that variable to be judged a drive Thus if habit strength and other factors are held constant, reaction tendency, or response strength is a direct function of drive magnitude Drive magnitude may be *operationally* defined independently of the definition of drive as a theoretical construct Operational definitions of drive magnitude may be stated in varying ways sometimes recognizing a distinction between aversive and appetitional drives and sometimes not As such a distinction appears to have little or no utility, it will be assumed that operational definitions of drive for the purposes of this chapter, will refer to some period and amount of a stimulus event either interoceptive or exteroceptive which is the object of avoidance and that operational definitions of drive magnitude refer to variations in the duration and amount of such stimulus events

In the case of primary drives at least drive magnitude is operationally defined as an increasing function of the duration or amount of the condition which is the object of avoidance, with the qualification that the function will not be expected to continue to increase beyond a duration or amount of the condition sufficient to result in physiological damage to the organism Thus, drive is operationally defined as a curvilinear function of duration or amount of the aversive condition (Figure 6–1)

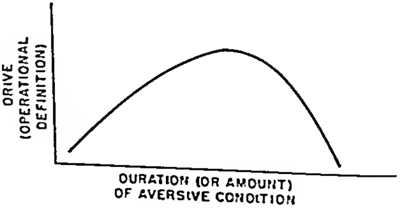


FIGURE 6–1

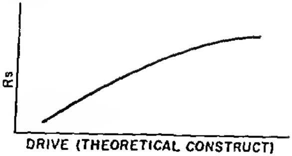


FIGURE 6–2

We have noted that drive, as a theoretical construct, is defined in such a way that response strength is an increasing function of drive (Figure 6–2).

Then, if a drive variable operationally defined (Figure 6–1) also satisfies the definition of drive as a theoretical construct (Figure 6–2), response strength under that drive will be a curvilinear function of duration or amount of the avoidance condition, increasing for an indefinite period, then decreasing as physiological deterioration occurs (Figure 6–3).

Thus, the theoretical construct *drive* may be considered demonstrated if response strength can be shown to increase over increasing durations or amounts of some condition which is the object of avoidance, from zero durations and/or amounts upward over an indeterminate range until physiological reactions, if any, may supervene. (It is acknowledged that not all *primary drives*, e.g., sex, are associated with physiological deterioration at their upper values.) *In the case of the sensory deprivation experiments* reviewed here, the responses are typically, but not always, instrumental responses associated with the reduction of the deprivation condition, and

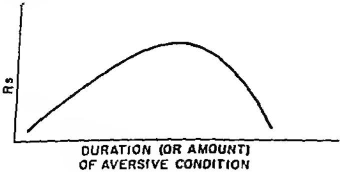


FIGURE 6–3

the drive variable happens to have been operationally defined in each case as variations in duration of deprivation rather than as variations in amount of deprivation

Incentives

An incentive is defined for this discussion as a theoretical construct referring to an object or event which serves as a reinforcer of instrumental activity In order to be sure that the reinforcement capacity or potential inheres in the event as specified by the experimenter (or in the dimensions specified rather than some others simultaneously present) the demonstration of an incentive variable requires that instrumental response assuming an appropriate level of drive be an increasing function of the degree or magnitude of the hypothesized incentive This statement is consistent with the incentive motivational principle of Spence (1956) according to which when habit drive and other factors are held constant response strength is a direct function of incentive potential (K) which is operationally related to the magnitude and certain other properties of the objects or events to which organisms direct consummatory behavior or in the case of negative rewards avoidance behavior

These statements as was true of the previous discussion of drive must be qualified at least regarding primary motivational phenomena when extreme magnitudes of such objects or events are considered The operational definition of incentive potential or of an incentive dimension as an increasing function of magnitude of the object or event toward which consummatory behavior is directed (rewards hereafter) is subject to the qualification that the function will not be expected to continue to increase beyond a magnitude of the reward which is sufficient to offset the drive which motivates the consummatory behavior Thus incentive potential is *operationally* defined as a curvilinear function of magnitude of reward (Figure 6–4)

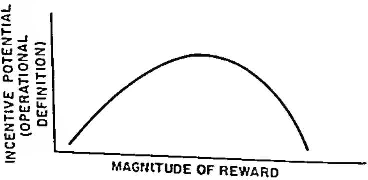


FIGURE 6–4

But as a theoretical construct incentive potential is defined in such a way that response strength is an increasing function of incentive potential (Figure 6–5)

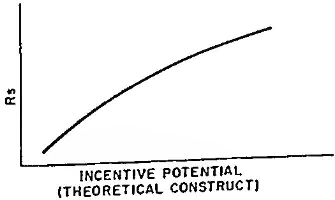


FIGURE 6–5

Thus in order for an incentive variable as operationally defined in Figure 6–4 also to satisfy the definition of incentive potential as a theoretical construct (Figure 6–5) it would be necessary to demonstrate that response strength is a curvilinear function of magnitude of the rewarding events or objects increasing over an indefinite range of magnitudes then decreasing as the drive motivating the instrumental activity is attenuated (Figure 6–6)

Whether response strength must necessarily decline at high magnitudes of reward or at what point may depend on the particular experi

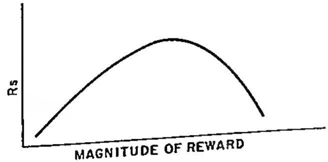


FIGURE 6–6

mental paradigm If actual consummatory activity is permitted rather than merely approach toward the reward it appears likely that the organism s tendency to respond for rewards of intermediate magnitude, consistent with its current drive level would be facilitated in comparison with the situation in which no consummatory activity is permitted and the magnitude of reward is perceived exteroceptively only without the subsequent additional and interoceptive perception associated with drive reduction The possibility is acknowledged in the latter case, that the function relating response strength to magnitude of reward may not always show a decline at high reward magnitudes The demonstration that a particular variable satisfies the definition of the incentive potential construct requires only that response strength be an increasing function of reward magnitude over some indefinite range of magnitudes from zero upward any subsequent decline in response strength is irrelevant to the verification of incentive potential In the sensory deprivation studies reviewed subsequently instrumental response has typically been followed by consummatory activity in that the organism has been immediately exposed to the sensory incentives and thus allowed to consume them perceptually In one instance however subjects responded for sensory rewards of varying magnitude but were denied exposure to the rewards until a later time In most but not all studies the incentive variable has been operationally defined as the amount or degree of variability associated with visual or auditory stimuli

EXPERIMENTAL PARADIGMS FOR DEMONSTRATION OF DRIVE AND INCENTIVE VARIABLES ASSOCIATED WITH SENSORY DEPRIVATION

Of the several experimental strategies available by which evidence of drives associated with sensory deprivation might be gained one has been employed almost exclusively in published studies to date that strategy will be referred to here as the consummatory paradigm Because of the probable importance of demonstrations of drive which hopefully will be attempted with other experimental strategies two further paradigms will also be considered in this section the escape and the avoidance paradigms

In the escape procedure the subject is maintained in a controlled environment of presumed aversive character and is permitted to execute an instrumental escape response Such a situation exists in virtually all sensory deprivation research since the subjects are nearly always if not always permitted to terminate the experiment before its scheduled completion or are asked to remain as long as they are able without any fixed duration Many experiments beginning with that of Bexton Heron and

Scott (1954) have reported data on subject drop-outs, but none appear to have utilized the escape paradigm for a direct test of the drive hypothesis In principle this would be a simple matter The independent variable would consist of different lengths or degrees of sensory deprivation following which the subject would be permitted an instrumental escape response Dependent variables would be latency or amplitude of the escape response or for subjects having received pretraining resistance to extinction Should latencies be found shorter and amplitudes greater over increasing lengths of deprivation support for the drive hypothesis would be inferred

The avoidance procedure is conventionally viewed as one in which the subject not presently experiencing the presumably noxious condition is permitted a response which will prevent or delay its occurrence No studies of motivational phenomena associated with sensory deprivation have been reported which employed this paradigm A variation of the avoidance procedure has been reported however by Rossi and Solomon (1964a 1964b 1964c 1964d) in which subjects experiencing sensory deprivation were permitted an instrumental response which earned them time-off in the form of shortened total durations in the experiment but which did not provide immediate escape or avoidance This promising technique could be extended to provide a direct test of the drive hypothesis by a design similar to that discussed under the escape procedure Subjects would be maintained in deprivation environments for varying periods of time before being permitted instrumental responses which are associated with time-off Should response rate be found an increasing function of the length of prior deprivation support for the drive hypothesis would be inferred

The third paradigm which permits a direct test of the drive hypothesis may be designated as the consummatory paradigm in which subjects are deprived for varying periods of time before being permitted to make instrumental responses serving to introduce into the deprivation environment stimuli possessing properties presumed to be motivationally relevant usually properties of variability conceived in various ways If the initial response rates are found to be an increasing function of the number of hours of prior deprivation a drive interpretation of the deprivation experience would be supported As noted above a very large proportion of the studies bearing on the drive hypothesis fall within the consummatory paradigm

Each of the three strategies indicated above appears adequate for the demonstration of a drive associated with sensory deprivation if such exists but each leaves unanswered the question of what the drive is for unless further experimental requirements are met Superficially it is observed that many subjects in sensorily deprived environments will perform responses which permit them to escape minimize or altogether

avoid future deprivation. A drive process may be tentatively inferred. But what aspect or aspects of the deprivation environment motivated the escape and avoidance responses? That is the question formulated so as to emphasize the energizing or drive process. Turning the question around so as to emphasize the incentive issue: what aspects of the extraexperimental environment served as the reinforcers of the escape and avoidance responses? In the consummatory paradigm, similar problems arise. What aspects of the deprivation environment motivate the responses for stimulation? And what are the attributes of the sensory rewards which reduce the drive associated with the deprivation condition? That sensory deprivation environments are not instances of unidimensional, perfectly homogeneous sensory restrictions will probably be readily agreed. Aside from the general conviction that deprivation of variability of stimulation is of prime importance rather than deprivation of sensory input *per se*, the precise conceptualization of deprivation environments remains to be achieved. That is, it is often reasonable to assert that a restriction of variability has occurred, but the definitions, dimensional analyses, and measurement of the variability remain unspecified. Similarly, the properties of the sensory rewards which reinforce the escape, avoidance, or consummatory responses are often not ascertainable. It appears clear that a full understanding of the motivational phenomena associated with sensory deprivation requires that the lack of variability of the deprivation condition and the variability of the sensory rewards be further analyzed.

It should be noted that many of the studies reviewed here bear on the drive and incentive phenomena in a manner that is incidental to the primary goal of the investigators; thus the evidence on these topics is often incomplete. This is apt to be the case particularly with regard to experiments in which the subjects are permitted to respond for meaningful, usually verbal, stimuli such as taped "propaganda" (e.g., Scott, Bexton, Heron, & Doane, 1959; Myers, Murphy, & Smith, 1963). Because of the extreme multidimensionality of such verbal stimuli, it is difficult to discern which are the attributes most motivationally relevant. Secondary reward phenomena contribute greatly to this difficulty. It appears likely that virtually all verbal stimuli are associated with some degree of secondary reward, either positive or negative, and that the differences among subjects in the secondary reward value of verbal stimuli are very great. A serious interpretive problem arises from the fact that the crucial incentive properties of the stimuli may have to do with their secondary reward value rather than with their variability *per se*. In addition, such meaningful verbal stimuli are often rich in associative value to the subjects, and the incentive properties of the stimuli may often lie in neither their variability *per se*, nor their immediate secondary reward value, but in the secondary reward value attached to the series of associations elicited by the verbal stimuli. Because the use of meaningful stimuli as sensory rewards

presents different, and usually more difficult, problems of interpretation than the use of nonverbal, 'meaningless' stimuli of presumably relatively low secondary reward value, these two classes of studies will be discussed separately in the sections that follow

EXPERIMENTS WITH MEANINGFUL STIMULI AS REWARDS FOR INSTRUMENTAL ACTIVITY

There has been, from the beginning of sensory deprivation research, a strong interest in the effects of deprived perceptual experience upon attitude change In Bexton s dissertation study (1953) eight subjects in a condition of perceptual deprivation were permitted to respond as they wished for such variable, meaningful stimuli as segments of a stock market report, soap commercials and religious talks for children In a pre-experimental procedure, the subjects were divided into two groups one of which was familiarized with the 'sensory rewards' which would be made available to them later, the other group receiving no such exposure at all During the deprivation condition, the group which had been familiarized with the materials responded for them only nine times while the group which had received no exposure to the materials responded for them 55 times As the groups had otherwise been treated similarly, it appears that the novelty or information value of the stimuli was responsible for the difference in response rates Bexton s results suggest that the deprivation condition gave rise to a drive process which motivated the responses for stimulation, and that the reinforcing attribute of the stimuli was their novelty or information value, rather than their variability or whatever secondary reward value they may have possessed as both of these factors were constant for the two groups Thus any drive process which we may tentatively infer appears to have been associated with the lack, in the sensory deprivation environment, of unfamiliar, novel, or informational stimuli (the latter term being used in its statistical sense) rather than with the lack of merely variable stimuli in the sense of varied stimulus elements arranged in at least partially irregular series, as in spoken English

Also suggestive of a drive variable was the fact that the rate of instrumental response increased substantially during the second half of the deprivation condition It is tempting to conclude that successively energizing effects of the cumulative hours of deprivation were responsible for the increased response rates, although quite possibly correct such an interpretation remains in doubt because of the possibility that successive increments in habit strength associated with the successive responses caused an increment in response rate independent of any change in drive level

In a subsequent study of opinion change (Scott, Bexton, Heron, & Doane, 1959), 24 subjects remaining in the deprivation environment after 18 hours were each exposed to nine "propaganda" lectures concerning psychic phenomena. The subjects were then permitted to request the lectures, one at a time, as they wished. Control subjects were exposed to the same lectures in a bare, lighted room, and were given the same opportunity to request that they be repeated. The perceptually deprived subjects made more responses for the lectures than did the controls. This study yields a clearer interpretation of the relationship between the sensory rewards (lectures) and the deprivation condition than does the preceding one because of the addition of the control group. Regarding the earlier study by Bexton, it would be possible to argue that the requests for the sensory rewards in the form of commercials, stock market reports, etc., may have been unrelated to the sensory deprivation experience and would have occurred similarly with subjects in nondeprived environments of comparable duration. The Scott experiment, however, provides evidence that there is particular motivational relevance to the deprivation experience. Because the demonstration of drive rests upon evidence that different degrees or durations of deprivation energize response to correspondingly different degrees, their results, being based upon one duration of deprivation only, 18 hours, are consistent with, but are not proof of, the existence of a drive variable. The design also does not permit a clear inference concerning the aspect or aspects of the taped lectures which were reinforcing. Where the earlier study (Bexton, 1953) showed that the novelty or unfamiliarity of the stimuli was the crucial dimension of reinforcement, the Scott experiment does not provide such a distinction. It is not possible to determine whether the lectures were responded to because of the reinforcing quality of their variability, novelty, secondary reward value, or possibly some further, unidentified characteristic.

An experiment from the HumRRO project of Myers, Murphy, and Smith (1963) provides what is, for the purpose of this chapter, essentially a replication of the Scott study, but with the period of deprivation prior to the introduction of the sensory rewards being greatly extended. After 48 hours in the deprivation environment, the experimental subjects were permitted to respond for 3 minutes of taped propaganda concerning the nation Turkey and its people as often as they desired during a 75 minute test period. Control subjects were maintained in lighted rooms. The response rate of the experimental subjects was again significantly higher than that of the controls. This replication with a considerably extended period of deprivation is useful because of its suggestion that the motivational process supporting response is not offset by continued exposure to the deprivation environment. Without comparisons of response following different periods of initial deprivation one could not rule out the possibility that the motivation for instrumental response aroused by the experi

mental condition rather than being a function of perceptual deprivation tends instead to be suppressed by it and increasingly suppressed by increasing durations of deprivation As a hypothetical example let us consider that the motivation for response for taped propaganda is principally an irrelevant drive anxiety associated with the ambiguities and novelty of the deprivation environment Relative to control subjects the experimental subjects would be expected to respond generally including requests for propaganda at a higher rate but as their experience with the deprivation environment continues, their anxiety should gradually decline and with it their response rate until the response function of the two groups would be indistinguishable Although research with still greater periods of deprivation would strengthen the argument the findings of the Myers Murphy and Smith study in comparison with those of Scott suggest that the motivation for instrumental response for verbal sensory rewards is related to the perceptual restrictions of the deprivation condition rather than to some irrelevant temporary correlate of the perceptual restrictions

A study of similar design has been reported recently by Smith and Myers (1966) in which the sensory rewards consisted of segments of a stock market report (e g Niagara Mohawk Power High 59 and 5/8 Low 59 and 5/8 Close 59 and 5/8 no change 2 100 shares traded Lab electronics High 9 and 1/2) Experimental subjects spent approximately 24 hours in a visually and auditorily deprived environment Control subjects spent a similar period in the same type of small room but with many recreational facilities such as television books and playing cards and a room light to be kept on as much as desired After 9½ hours all subjects were allowed for one hour to respond (lever pressing) for the stock market report as often as they wished The experimental subjects again responded significantly more often than did the controls indicating that the reinforcing character of the verbal stimuli was maintained even though relative to the propaganda stimuli of the preceding studies they were much less meaningful and presumably much more boring The experimental procedure was repeated on a second day and the interaction of the days and conditions although a statistical test was not reported shows a trend of considerable relevance to the present discussion From the first to the second day the response rate of the experimental subjects dropped about 40 percent while that of the control group increased about 100 percent If significant this trend suggests that the response rate of the experimental subjects may have been enhanced initially by irrelevant drive factors such as apprehension or excitement associated with the strangeness of the deprivation environment and that by the second session such factors had dissipated allowing response rate to fall to a level associated with the motivation aroused by the perceptual restrictions For the control subjects in contrast the first day was associated with only a

slight degree of perceptual restriction (that associated with confinement to their rooms) without the facilitating effects of anxiety or excitement anywhere near the level that might be surmised as having been experi enced by the experimental subjects with consequently a very low re sponse rate less than 20 percent of the experimental group s rate In order to account for the sharp rise in response rate on the second day it seems reasonable to conjecture that boredom successfully deferred on the first day by the recreational facilities provided was beginning to increase and that the verbal stimuli were of correspondingly greater motivational relevance

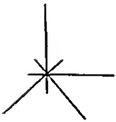
In a second study employing similar procedures Smith Myers and Johnson (1967) extended the total period of deprivation to 7 days Subjects were permitted to respond during the 6th 78th and 150th hours for the segments of a stock market report Response rose sharply for the experimental group the rate during the 78th hour being approximately 53 percent greater and during the 150th hour approximately 84 percent greater than that during the 6th hour Over the same interval the re sponse rate for the control group declined approximately 50 percent These trends over 7 days are of course quite the opposite of those obtained in the prior study over 2 days Had the 7-day experimental group been tested at but a 24 hour interval after the initial test as in the prior study it is possible that they also would have shown a decrement in re sponse rate perhaps due to a decrement in anxiety or other irrelevant drives In any case however the cumulative effect of 78 hours of depriva tion was sufficiently motivating as to offset the effect of any such temporary decrements in irrelevant drive The finding of increasing response rate over the period of 7 days is of particular interest in suggesting a drive process associated with sensory deprivation Because of the possibility that the increased response rates reflect successively greater levels of habit strength rather than drive however it is not possible to conclude that the theoretical construct drive has been demonstrated The finding is nevertheless of considerable importance in seeming to rule out the possi bility that response for such stimuli is motivated by transitory spurious motivational variables not directly related to sensory deprivation *per se*

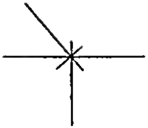
In summary five studies reviewed each representative of the con summatory paradigm appear to support clearly the view that sensory deprivation motivates stimulus-seeking responses where the stimuli are of a meaningful verbal sort They do not provide evidence however as to whether such motivation satisfies the demonstration of the drive construct as none included a comparison of the differentially energizing effects of different degrees or durations of deprivation Few clues were provided also as to the identification of the attribute or attributes of the stimuli which determined their reinforcement value The principal lead on this topic was provided by Bexton s (1953) study in which it appeared that the

reinforcing value of the verbal stimuli lay principally in their unfamiliarity to the subject rather than in their inherent properties

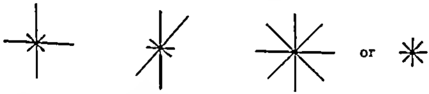
A variation of the avoidance paradigm is represented by a series of experiments by Rossi and Solomon (1964a 1964b 1964c 1964d) in which subjects serving in deprivation environments for 3 hours were permitted to make button pressing responses which they were led to believe would earn them a reduction in the total duration of deprivation That these experiments are considered under the present section which is concerned with studies employing meaningful stimuli as rewards may seem arbitrary at first thought Consider however the nature of the reward as the subject perceives it The subject believes that he will receive time-off i e that the end of the deprivation condition will occur sooner thereby releasing him earlier into the environment outside the experimental chamber—an environment which although not specified in the research report is undoubtedly a complex and meaningfully patterned environment for each subject Although a majority of the subjects did respond to some extent for time-off suggesting that the condition was aversive a substantial proportion did not respond at all—four out of ten subjects in one experiment seven out of 15 in another and five out of 18 in a third There were in addition an unspecified number of subjects with very low response rates Thus some doubt is raised as to the aversive status of sensory deprivation of 3 hours duration Rossi and Solomon unlike perhaps most investigators in this area have reported specific data on nonresponding subjects It may well be that similar doubts would be raised about the aversive character of the longer periods of deprivation employed in other studies had the investigators reported comparable data

The Rossi and Solomon experiments were not directed principally toward an understanding of drive and incentive phenomena but were instead concerned with such topics as the relationship of the instrumental response rate to descriptions of experience to changes in ratings of well being and to differences in the physical discomfort of the deprivation environment One experiment however bears more closely than the others on a possible drive interpretation (Rossi & Solomon 1964b) Subjects were permitted to respond for what they were led to believe would be time-off at the rate of 1 minute 2 minutes or 3 minutes for every 200 presses Response rate was found to be a significant increasing function of the magnitude of the time-off rewards This finding supports the interpretation that the motivation for responding was related to the aversive character of the deprivation condition whereas the absence of such a relationship would have suggested that response was determined principally by spurious unknown nonaversive factors Rossi and Solomon s data are thus consistent with a drive interpretation but as with the prior studies do not constitute proof of a drive variable because of the absence of comparisons of response rates following different periods





For the subject viewing them, they would be identified as having maximal information value (maximal because they were arranged in a *totally* random fashion) if he had no basis for prediction of the arrangement of the long and short lines If he knew in advance what the stimuli would look like, i e , if they were entirely predictable, the same stimuli would be correctly designated as having maximal complexity A totally nonrandom (i e , symmetrically or regularly patterned) arrangement of lines would have zero complexity value, but some fluctuation value according to the degree of alternation of long and short lines The following are examples of maximal, intermediate and zero fluctuation values



or

Maximal Intermediate Zero

Although the above examples are of visual stimuli, in principle the distinctions between information complexity, and fluctuation should be applicable to stimuli of all modalities whether in discrete or series form

Escape Paradigm

Of the studies employing nonmeaningful sensory rewards, none fall within the avoidance paradigm and only one within the escape paradigm Vernon and McGill (1960) have reported a study employing a variation of the escape paradigm in which the escape response constituted the independent variable rather than the criterion measure Fifteen subjects scheduled for 3 days of sensory deprivation were permitted to respond (button pressing) for exposure of a discrete visual stimulus consisting of a large and a small circle with a slanting line between them For those subjects (N = 6) who requested early release from the experiment (after an average of 37 6 hours) the average amount of time spent viewing the stimulus was more than 13 times greater than the average amount of time

spent by those subjects ($N = 9$) who completed the experiment It seems reasonable to assume that the early release group experienced the deprivation environment as more aversive than did the stayers i e that they were under a higher level of drive If this assumption is correct then the instrumental response rates of the two groups should permit some inference as to the attributes of the environment which were drive inducing Had the two groups responded at a similar rate we would be forced to conclude that the absence of such visual stimuli as was represented by the figure contingent upon response did not constitute the aversive attribute As it happened however the large and statistically significant difference in mean response rates is strongly suggestive of a drive process associated with the deprived visual experience In contrast to the relatively high values of information and complexity which characterized the meaningful sensory rewards discussed in the preceding section Vernon and McGill s subjects viewed repeatedly a single stimulus consisting of three geometric elements Except possibly for the first one or two exposures the stimulus was presumably entirely predictable by the subjects and thus exposure to *it* was not *associated with* any *information value* As the computation of the randomness of the spatial or sequential arrangement of stimulus elements requires that they each appear more than once the complexity value of the sensory reward is also at zero Thus the variability of the sensory reward is associated with the lowest of the three hierarchically ordered dimensions fluctuation satisfying the criterion of that dimension simply because the three stimulus elements are not identical but are drawn from different categories in this case categories of size and contour The inference is suggested that the subjects experienced a drive *for* visual stimulus fluctuation If true this finding would not rule out the possibility that other *drives* for *stimulus information* and complexity might not be induced by sensory deprivation but at the same time the possibility is raised that the motivationally relevant dimensions of the sensory rewards employed in the previously reviewed studies may not be either information or complexity but simply the subordinate dimension of fluctuation Although Vernon and McGill s findings are consistent with the interpretation of a drive for stimulus fluctuation the experimental design does not permit an unequivocal test of the drive hypothesis One obstacle lies in the *fact* that *the early release subjects* may have experienced *the deprivation as more* noxious than the others in a way not necessarily *related* to the visual restrictions and that the greater *aversiveness* of the situation in accordance with the principle of generalized drive more strongly energized a wide range of reactions including button pressing than was true of the stayers A control for this interpretation would have been the inclusion of a blind button the pressing of which did not result in any increase in stimulation *Had the* differential in response rate between the two groups been *greater for the stimulus*

button than for the control button, the inference of a drive process specific to the visual restrictions would have been supported

Consummatory Paradigm

Incentive Phenomena Jones and his associates at the University of Pittsburgh have conducted a series of experiments in which the subjects, after varying initial periods of sensory deprivation up to 48 hours were allowed control of apparatus which could be used to introduce sequences of visual or auditory stimuli into the deprivation environment as the subjects wished throughout the balance of the session In the first study of the series (Jones Wilkinson, & Braden, 1961), subjects lay on beds in light proof, sound insulated chambers for 10 hours After 1 hour for half the subjects and after 5 hours for the others they were permitted to press a button which initiated a series of 24 brief red and green light flashes at 1 second intervals and to vary the position of a dial which controlled the information value of the series The light flashes were of very low intensity, although readily perceived by the dark adapted subjects and were located 3 inches apart on the ceiling above the foot of the subject's bed The information value of the series was varied by causing the succession of red and green flashes to be randomly determined to different degrees A maximal information series (with a relative information value of 1 0) consisted of an entirely random succession of red and green flashes which was always unpredictable because further selections of the series resulted always in a new randomization, thus, except by chance, no two series of 24 flashes would show the same succession of red and green lights Intermediate degrees of information were established as before except that the flashes occurring in certain serial positions were of a fixed or predictable, color For example in a series with relative information value of 0 67, every third flash was of a fixed constant color (red for half the subjects, green for the other half) with the intervening flashes being given a new random determination upon each selection of that series Similarly, in a series with relative information value of 0 33 only every third flash was random and unpredictable, the remaining two thirds being of fixed color Zero information value was represented by a series of a single color

Response rate was found to be a significant, increasing function of information value, the response rate for maximal information being approximately three times that for zero information A replication of the experiment employing auditory stimuli (sequences of high and low tones) yielded almost identical results suggesting that the reinforcing character of informational series is probably not specific to particular modalities (Jones & McGill 1967, Exp I) It will be recalled that the proof of an incentive dimension rests upon the demonstration that response strength increases with increasing values of the hypothesized incentive If that result cannot be shown it would have to be concluded that the dimension

which was varied was not that which was critical for reinforcement and that the true dimension of reinforcement lies in some undesignated aspect or aspects of the objects or events employed as rewards In the present experiments the demonstration of an incentive principle was satisfied by the increasing trend of responses over information values

While there seemed little doubt but that an incentive dimension was established some ambiguity remained as to the correct identification of the incentive dimension It could be argued that the subjects might have shown the same function of response over the increasing values of randomness even if the series representing particular values of randomness had been repeated exactly no matter how often the subjects responded for them That is the subjects might have responded exactly the same whether the series were random only (having complexity value) or random and also unpredictable (having information value) In order to resolve this question a series of further experiments (Jones 1964b) was carried out in which the incentive properties of information and complexity were compared by making available to the subjects comparable values of the two dimensions A maximal complexity series for example consisted of an entirely random sequence of red and green light flashes which was repeated exactly each time the subject selected that series A maximal information series consisted of an entirely random sequence of red and green flashes differing from the complexity series in that each selection of the series resulted in an independent (and hence unpredictable) randomization of the sequence Subjects response rates were compared over the relative information and complexity values 0 00 0 50 and 1 00

The results were in certain respects surprising When subjects had available to them only information or complexity series their response functions were in some respects similar with response rate being much the highest for maximal values (1 00) of each dimension but where the response function for information was increasing and monotonic the function for complexity failed to meet that criterion of an incentive dimension because the response rate for zero complexity was elevated above that for the relative complexity value 0 50 Because the function was otherwise increasing and linear however and because the analysis of variance showed both the linear and quadratic components to be significant we shall speak tentatively of the incentive properties of high values of complexity noting that the requirements of an incentive dimension were not met The evidence for the incentive properties of even high complexity series failed to emerge however when subjects were simultaneously permitted to respond for comparable values of both dimensions Response rate was again found to be an increasing linear function of information values but the strong preference for maximal complexity over lesser complexity values failed to appear in fact the response rate for maximal complexity was but very slightly and nonsignificantly greater

than that for zero complexity It appears that the incentive properties of stimulus information are sufficiently the stronger that they effectively suppressed the incentive properties of stimulus complexity when both were simultaneously and equally available to subjects Thus the statistically superordinate information variable is motivationally superordinate as well As both the complexity and information dimension were at zero in the deprivation environment preceding the period of instrumental response (because of total absence of photic stimulation) it may be inferred that the drive process if any existed was principally a drive *for* stimulus information

Because the incentive properties of the complexity series are in turn confounded with the possible incentive properties of fluctuation series the Jones (1964b) study continued with a comparison of these two variables It might be argued for example that the reinforcement value of the high complexity series lies not in the randomness *per se*, of the sequence of stimulus categories but simply in the fact that the more complex series contain more instances of fluctuation of stimulus categories and that subjects would respond just as discriminatively for increasing values of fluctuation in series which are totally nonrandom and thus have zero complexity A series of maximal fluctuation value it will be recalled is of the form A B A B A B When subjects were limited to comparable values of *either* complexity or fluctuation series (but not both) their response functions were found to be almost identical with response rate being greatest for maximal values of either variable As complexity is superordinate with respect to fluctuation just as information is superordinate with respect to complexity it was expected that when subjects are allowed to choose between comparable values of *both* dimensions the incentive properties of complexity would be shown to be the greater with a suppression of the incentive properties of the fluctuation series which were simultaneously and equally available Intuitively it seemed reasonable that a physically random although repetitive stimulus such as A B A A B A B B B A would have greater reinforcement value than the single alternation A B A B A B Such was not the case however The response functions over comparable values of the two dimensions now tested in a competitional situation were again almost identical indicating that the incentive properties of complexity series are reducible entirely to the degree of fluctuation of stimulus categories rather than to the degree of randomness in the sequence of categories Thus randomness of sequence *per se* does not appear to have any status as an independent dimension of sensory incentives

Corroboration of the incentive properties of informational series of visual stimuli has been provided by several other studies conducted in the University of Pittsburgh laboratory (Jones 1961 Thornton & Jones 1965 Jones Gardner & Thornton 1966 Levin & Brody 1966) Support for the

incentive property of stimulus information has also been provided by an experiment by Zuckerman and Haber (1965) in which subjects were permitted to manipulate a three position switch as they wished throughout a 3 hour session of visual and auditory deprivation One switch position provided a 15 second exposure to a random series of colored strips painted across a blank film strip a second position provided a 15 second series of tape recorded tones with choice and order of notes randomly determined and the third position which activated no stimulation was included as a control Because the series of tones and colored strips were each continuously randomized so that subjects were not able to predict them they were of maximal information value A feature of the design unique to this experiment was the attempt to insure some general psychological equivalence of the two sets of stimuli In a pilot study subjects rated both the color and tone sequences on 14 scales drawn from Osgood s Semantic Differential research (1957) the evaluation factor was measured by six scales the potency factor by four and the activity factor by four Because the ratings indicated the visual stimuli to be more potent than the auditory stimuli the latter were increased in amplitude At the beginning of the experiment proper both series were rated as equivalent on all three factors The results suggest that the reinforcing value of the stimuli was considerable Subjects were required to respond ten times in order to initiate a stimulus series The mean response rate pooled over auditory and visual series was 1 942 thus subjects responded for an average of 194 series of 15 seconds duration No responses were made with the switch in the neutral position The experimental design did not permit a direct test of information as an incentive dimension because only one value of information was employed but the results are highly consistent with those reported by Jones and his associates Of particular interest was the comparison of response rates for the visual and auditory series response for the visual series was significantly greater than for the auditory series, the mean rate being more than twice as high The strikingly greater motivational relevance of the visual stimuli is a topic to which we will return in a later section which includes a discussion of Thornton s (1966) comparison of information satiation effects in the visual and auditory modalities

Corroboration by other investigators of the incentive properties of complexity stimuli in deprivation conditions is very limited although several investigators have assessed the reinforcing value of the complexity dimension in nondeprivation conditions (e g Berlyne 1957 Munsinger & Kessen 1964) A single study by Goldstein (1965) bears indirectly on the incentive properties of complexity stimuli After 19½ hours of deprivation subjects were permitted to respond for a discrete complex visual stimulus Card VI of the Rorschach test and for a discrete complex auditory stimulus a tone mixture (It is difficult to evaluate the stimulus properties of the Rorschach card and although the experiment is included

in this section as an instance of using nonmeaningful sensory rewards, it is acknowledged that associative reactions to the stimulus may have been strong, and that the stimulus may have had considerable secondary reward value for some subjects.) Deprived subjects responded more often for each stimulus than did nondeprived controls, and response for the visual stimulus was more frequent than for the auditory stimulus. Because of the probable differences in associative and learned reward value between the two stimuli, however, it cannot be concluded with confidence that the results reflect a general difference in the motivational relevance of visual and auditory stimuli.

Two studies have been reported which deal with the possible incentive properties of nonvariable stimuli, that is, discrete signals which show no fluctuation. In the first of these (Myers, Murphy, Smith, & Goffard, 1966), subjects were permitted, during a 40-minute test period following 48 hours of deprivation, to respond for either a brief 500-cps tone or a comparable period of low-volume white noise. As compared with nondeprived controls, the sensorily-deprived subjects failed to show a significantly greater response rate. Many subjects expressed irritation and annoyance with the stimuli, and some seemed ambivalent in their attitudes. The investigators commented that, "Even though a Cubicle subject might want to hear a 500-cps tone more than did a Control subject, he might also be more annoyed by it when it did come on" (p. 74). The same investigators, in a further experiment, found that subjects who had been sensorily deprived for 76 or 96 hours significantly more often responded for the *cessation* of auditory signals during a 30-minute "satiation" procedure than did nondeprived controls. In some of the earlier experiments by Jones and his associates cited above, white noise was employed for its masking effect, but was discontinued because subjects often complained of the discomfort, even though they had been wearing beeswax and cotton earplugs which greatly attenuated all sound. Although merely conjectural at this point, it appears possible that such reactions may be a function of greatly decreased pain thresholds. This interpretation is suggested by the experiment of Vernon and McGill (1961) in which the reduction of pain thresholds associated with electric shock in subjects who had completed 4 days of sensory deprivation was more than five times greater than the reduction in thresholds which occurred with control subjects as a function of their second testing after a comparable period in a normal environment.

The second study dealing with the possible incentive properties of discrete, nonvariable stimuli is composed of two closely related experiments by Berkman (1966) and Tulchinsky (1966), which utilized a common control group. Tulchinsky's experiment was actually designed to assess the magnitude of the information drive by ascertaining the highest magnitude of shock which the subjects would voluntarily undergo in order to receive the reward of a series of random and unpredictable

stimuli This variation of the obstruction method originally employed in animal experimentation (Warden & Nissen 1928) is based upon the assumption that the *shock does* in fact function as a barrier or obstruction to response and to be sure that that was the case a control group was included which received shock only The completely unexpected result however was that the shock did not significantly inhibit response instead the control subjects with no other *reward than shock* responded for *more intense* shock than did the experimental subjects Both groups were maintained in sensory deprivation environments for 8 hours From the end of *the first hour* the experimental group was permitted to respond for a shock administered immediately to the forearm which was in turn followed promptly by the positive reward a series of visual stimuli of maximal information value The control group was from the same point *allowed to respond for shock only The first shocks administered were set* at near threshold levels for all subjects with succeeding shocks intermittently increased in imperceptible or barely perceptible degrees according to a standard prearranged schedule The dependent variable of prime interest was the shock intensity in milliamperes associated with the subjects last response before the termination of the 7 hour period of responding All subjects participated in both a pre and immediately postexperimental scaling of their reactions to shock in which they indicated according to the method of limits the shock intensities which were minimum perceptible irritating painful very painful and a fifth intensity which was the *maximum tolerable* i e *the greatest level of shock which* the subject would accept It was emphasized that the research was exploratory in character that the experimenters had no preconception as to how often or seldom the subjects would respond and that the procedure was not intended as a measure of any personality factor such as resistance to stress To both the experimental subjects (shock plus visual information) and the control subjects (shock only) the experiment was introduced as an attempt to discover whether or not certain kinds of stimulation are useful in the alleviation of boredom The gradual upward drift in shock intensity was rationalized as a technique for offsetting the normal adaptation to shock which would be expected to occur over such a period of time A comparison of the pre- and postexperimental scaling of shock showed a slight and nonsignificant tendency to adaptation—i e a rise in threshold—in surprising contrast to the findings of Vernon and McGill (1961) Consequently the intensity of the shock associated with the subjects final response was described in terms of the postexperimental scaling For the experimental group the mean *shock* intensity associated with the final response was not significantly different from that associated with the mean judgment of painful while for the controls the final response was associated with a mean *judgment of very painful* Several subjects in both groups accepted during the deprivation condition shock intensities

greater than those which they designated as their upper limit in the immediately following postexperimental scaling

Berkman's (1966) experiment, employing generally similar procedures attempted to determine whether the reinforcing character of the shocks could be enhanced by attaching information value to them, i e by making them to a certain degree unpredictable Berkman was principally interested in analogues of behavior customarily designated as masochistic in a clinical context The response of subjects for stimuli which they regard as painful and which are ordinarily (i e, outside the experiment) the object of avoidance, meet the behavioral criteria of masochistic behavior quite closely As nonpainful informational stimuli had been shown in prior studies (e g, Jones Wilkinson & Braden, 1961) to have significant incentive properties it was reasoned that electric shock stimuli which contain information value should be responded for more often than shock stimuli which are redundant or predictable Should this be found to be the case it would suggest that much of the motivation for seemingly masochistic behavior may not be motivation for pain *per se*, but motivation for the novel or informational character of the stimuli The experimental group was permitted, after the first hour of an 8-hour deprivation period to respond for shock as often or as seldom as they wished The apparatus consisted of a two-position dial and a button A button press with the dial in the first position activated a probability program which administered immediately a shock to the forearm on 50 percent of the trials according to a random schedule On the remaining trials nothing happened Thus each trial was informational in that its shock nonshock status could not be predicted Because of the possibility that subjects might respond for the information shocks because of their value on the subordinate fluctuation dimension the second dial position served as a control which delivered shocks on a 50 percent alternation schedule That is every other button

trol subjects were receiving shock following approximately one half their responses the mean number of shocks received by the control group was more than twice the number received by the experimental group This latter comparison which is statistically significant is difficult to interpret It seems likely that reinforcement ratios and schedules are involved It also appears probable that response for the informational shocks may have been partly inhibited by fear associated with their unpredictability a factor absent in the control group There was no significant difference between the experimental and control groups regarding the semantic judgments associated with the shocks they received during the deprivation condition For the experimental group eight out of the nine subjects successfully completing the session responded for shocks at or above the intensity they had judged painful and four subjects responded for shocks at or above the intensity judged very painful Within the experimental group the frequency of response for the information shocks was greater but not significantly so than that for the fluctuation shocks

Considered together the results of the Berkman and Tulchinsky experiments appear to indicate that the discrete shock stimuli of almost perfectly predictable intensity which were at first minimally uncomfortable but which rose to intensities which most subjects described as painful or worse functioned as strong *positive* rewards The highly unexpected nature of these results elicited a certain amount of paranoia in the investigators. In order to be sure that the subjects verbal ratings of shock intensity did not represent gross inflations of actual subjective discomfort the laboratory personnel informally evaluated their own reactions to the shock series and were in agreement that shocks which subjects reported as painful and very painful were in fact distinctly aversive from their standpoint also Although the possibility cannot be ruled out altogether that some distortion in the subjects labeling of their discomfort reactions occurred it appears very unlikely that any such distortions as may have occurred represented a systematic bias of any appreciable degree

Drive Phenomena In the first of the experiments reported by Jones and his associates (Jones Wilkinson & Braden 1961 Exp 1) subjects were permitted to respond for visual information series from the beginning of 12 hour sessions Response rate rose sharply over the first 9 hours of the session falling off slightly in the last 3 The initial period of increasing response rate is highly suggestive of a drive process but not conclusive because of the possibility that the successive increments in habit strength associated with successive responses may have been sufficient to accelerate response rate to the extent observed without the necessity of drawing upon a drive interpretation In the second experiment of the Jones Wilkinson and Braden study that confounding of variables was avoided by maintaining half the subjects in deprivation for 1 hour before permitting them to respond the other half for 5 hours Any differences in response rates for

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The results were again in the direction contrary to that predicted The mean number of responses for the controls was *greater* than that for the experimental group pooling responses for both the fluctuation and information alternatives although not significantly so Because the con

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the two groups over comparable periods of time after those periods of initial deprivation could not be attributed to differences in habit strength. The data supported the drive hypothesis. The 5-hour deprivation group in their first hour of access to the visual incentives responded at a higher rate than did the 1-hour deprivation group. Over the following 4 hours the response rates for the two groups converged, presumably as the differential energizing effects of the initial periods of deprivation dissipated over time. Subsequent experiments in the University of Pittsburgh laboratory confirmed the drive interpretation in comparisons of groups deprived for substantially longer periods. Gardner (1961) maintained twelve subjects in lightproof, sound-insulated chambers for 48 hours, with half the subjects denied access to the visual incentives for 5 hours, the other half for 24 hours. The mean response rate of the 24-hour group was significantly higher than that of the 5-hour group over comparable periods of access to the visual incentives. The experiment which followed (Jones, Gardner, & Thornton, 1966, Exp. II) extended the comparisons to groups deprived for 0, 24, and 48 hours before being allowed access to the visual incentives for the balance of 96-hour deprivation sessions. The drive hypothesis was again supported: response rate was a highly significant ($p < .001$) linear function of the number of hours of prior deprivation.

The considerable evidence for a drive variable associated with sensory deprivation bears importantly on the view of Hebb (1955) and some others that arousal, as measured by ARAS activity projected to the cortex, is synonymous with the concept of drive. If we may assume that Hebb's use of the term drive is consistent with the S-R reinforcement theory definitions employed in this chapter, then the evidence for information drive would seem to refute his view. Zubek and his associates (Zubek, 1964a; Zubek & Welch, 1963; Zubek, Welch, & Saunders, 1963) have reported several experiments showing that both perceptual and sensory deprivation resulted in progressive decrements in mean occipital frequency, an indication of *decreased* ARAS arousal. Yet the experiment of Jones and his associates and the experiment of Smith and Myers cited in a preceding section show that drive as measured behaviorally *increases* over days of sensory deprivation. Thus, arousal as measured by ARAS activity is not synonymous with drive, and Hebb's theory would seem to require revision. A further complication for the arousal theories is provided by the fact that autonomic arousal as measured by the GSR *increases* as a function of hours of sensory deprivation rather than decreases, as does cortical or ARAS arousal. In the Vernon, McGill, Gulick, and Candland (1961) experiment, for example, measures were taken before and at the end of deprivation periods of 24, 48, and 72 hours. In each case arousal increased (resistance decreased), and the magnitude of the effect was an increasing function of hours of deprivation. That the GSR as a measure of autonomic arousal converges with drive, as behaviorally defined, is demonstrated

in a particularly interesting way by Zuckerman and Haber (1965) These investigators selected from the subjects of a prior experiment (Zuckerman Levine & Biase 1964) twelve individuals who showed high autonomic (increased conductance) measures during sensory deprivation and twelve who showed low arousal Both groups were then maintained in sensory deprivation for 3 hours during which they were permitted to respond for random visual or auditory stimulation The high GSR reactors (high autonomic arousal group) responded significantly more often than did the low GSR reactors (low arousal group) The effect was both of great magnitude—response frequency being almost four times greater for the high arousal group—and highly reliable ($p < .001$) The results suggest that autonomic arousal as measured by GSR may serve as a predictor or inferential measure of the drive associated with sensory deprivation

According to the formulation of Spence (1956) and Hull (1952) drive processes operationally defined in different ways and associated with different organ systems summate to determine a level of generalized drive which impartially energizes all reaction tendencies existing at the time This aspect of the drive construct was assessed with regard to the drive for stimulus information in an experiment reported by Jones (1961) in which all subjects were permitted to respond for visual information series from the beginning of 8 hour deprivation sessions One experimental group served under a moderate level of irrelevant hunger drive having been deprived of food for 14 hours at the beginning of the deprivation period with food deprivation continuing throughout the 8-hour session A second experimental group experienced no food deprivation but was administered uncomfortable electric shocks to the forearms at unpredictable and irregular intervals during the experimental session For this group the irrelevant drive was considered to be principally the anxiety associated with electric shocks rather than the pain itself because of the small number (ten) and brief duration (1 5 sec) of the shocks. According to the drive summation principle the characteristic function of response for information incentives over time as exemplified by the control group should be displaced upward most strongly when the irrelevant drives are at their peak less strongly at other times In comparing the control with the hunger group from whom irrelevant drive was presumed to rise to its peak near the end of the session it was predicted that the irrelevant drive manipulation would show little effect on response during the first few hours but that relative to the control group the response rate of the hunger group would be disproportionately high toward the end of the session Conversely because of the expectation that the anxiety associated with shock would diminish as the session progressed it was predicted that the response rate of the experimental group relative to that of the control group would be disproportionately high in the early hours of the experiment Both predictions were confirmed with $p < .01$ and $p < .05$ for the

hunger control and shock control comparisons respectively Thus the interpretation of information deprivation as a drive variable is given additional support by the demonstration of its summation with irrelevant drives in the determination of instrumental response To the best of the writer s knowledge no other experiments concerned with the effects of irrelevant drive on stimulus seeking behavior have been reported Suedfeld Glucksberg and Vernon (1967) however have reported an experiment in which sensory deprivation as an irrelevant drive condition was found to facilitate problem solving performance on a task presumably unrelated or minimally related to the sensory deprivation experience As contrasted with the Jones (1961) experiment this experiment extends the status of the drive interpretation of sensory deprivation by providing a demonstration of the summation of drives in which the drive associated with sensory deprivation constituted the irrelevant rather than the relevant drive

In the experiments by Jones and his associates already noted the drive demonstrations have assumed that the drive was *for* the informational property of the sensory incentives principally or exclusively rather than for the subordinate properties of complexity and fluctuation and that it was the absence of unpredictable or informational stimuli in the visually deprived environments which energized response In the study discussed under *incentive phenomena* which compared the incentive properties of information complexity and fluctuation series (Jones 1964b) a comparison of the drive variable associated with each of the three dimensions was also undertaken The strategy of these comparisons was based on the assumption that the response rate of subjects permitted to respond from the beginning of the session should rise over the first several hours as a function of the increasingly energizing effect of successive hours of deprivation It was acknowledged that this would not be *sufficient* evidence of drive because of the possibility that the effects were due to successive increments in habit strength alone but it was reasoned that failure to show such an increasing response function already demonstrated with regard to response for informational incentives would constitute evidence against a drive process or at least evidence that any drive process that might exist is of very low magnitude relative to that of information drive The results constituted strong evidence against drives for stimulus complexity or fluctuation suggesting strongly that it is the omission or decrement in stimulus information which energizes reaction tendencies during sensory deprivation rather than the omission or decrement in the other dimensions of stimuli The possible drive phenomena associated with the complexity and fluctuation dimensions were each assessed twice once with subjects responding only for those attributes of stimulus series and once when series of the immediately superordinate variable were simultaneously present in a competitional situation (information

as the superordinate variable for complexity and complexity as the superordinate variable for fluctuation) In none of the four assessments did response rate for either complexity or fluctuation incentives show the characteristic increasing function over the initial hours of deprivation which is associated with response for informational series

Although personality effects of sensory deprivation have received attention in several studies and also personality correlates of isolation tolerance (both reviewed by Schultz 1965) there has been but a single study of personality correlates of the drive for stimulus information Levin and Brody (1966) investigated the relationship between creativity as defined by Mednick s (1962) Remote Association Test and information drive by visually depriving high and low creative subjects for 1 or 5 hours before permitting them to respond for visual information series as they wished throughout the balance of the 8 hour session There was no significant difference in response between the high and low-creative subjects deprived for 5 hours before being permitted to respond but in the one hour deprivation group the high creative subjects responded about ten times as often during the first hour of access to the informational incentives as did the low creative subjects thereafter falling off gradually For the low creative subjects in contrast response rate was very low for the first 2 hours then increased sharply overtaking the response rate of the high creative group in the sixth hour The differences between the two groups although in the same direction were not significant when the 5 hour subgroups were compared The results suggest that creativity is strongly related to information drive that sensory deprivation quickly induces information drive in high creative subjects but does so only after a considerably longer period in low creative subjects whose chronic level of information drive in the extraexperimental environment is presumably at a correspondingly lower level

EVIDENCE FOR A HOMEOSTATIC INFORMATION DRIVE

The studies reviewed thus far have been concerned exclusively with the drive and incentive phenomena associated with decreased stimulus variation Jones and McGill (1967) however have recently reported a study concerned with the hypothesized drive inducing effects of extended periods of highly variable stimulation The theoretical formulation underlying the study was that conditions of relatively great decrements in stimulus information and conditions of relatively great increments in stimulus information are associated with equal and opposite drive states in which subjects will learn and perform instrumental acts which serve respectively to increase or to reduce stimulus information This formula

tion it should be noted is not concerned in any way with intensity of stimulation and thus has little relationship to studies of the noxious effects of continued noise visual fatigue etc The study conducted as two separate experiments consisted essentially of a comparison of the incentive functions obtained under conditions of information deprivation and information satiation In the first experiment subjects were permitted to respond for informational series of high and low tones broadcast at 1 second intervals in 10-hour sessions of auditory and visual deprivation The relative information values available to theme were 0 00 0 33 0 67 and 1 00 the first referring to entirely predictable series the last to totally random and unpredictable series As noted in an earlier section response rate was an increasing linear function of the information values of the series This incentive function obtained under information deprivation served as the reference against which the effects of satiation were to be tested It was reasoned that following a condition of information *satiation*, the preferences should shift away from series of 1 00 information value toward series of 0 00 information value The satiation condition employed in the second experiment, required subjects to listen to maximally unpredictable tone series (1 00 information value) for 1 hour for half of the subjects and 5 hours for the other half before being permitted access to the apparatus controls for the balance of the 10-hour session The continuous series of tones was broadcast without interruption at the rate of 1 per second Once allowed control of the apparatus the subjects were free to select informational series over the range 0 00 0 33 0 67 and 1 00 but could not turn the signals off thus the second half of the experiment consisted of a forced-choice condition If the satiation procedure induced a drive process in the subjects which was associated with the noxious character of the maximally unpredictable series then response in the forced choice condition should show a shift toward lower information values relative to the preferences established under deprivation and the degree of the shift toward lower information values should be greater in the group satiated for 5 hours than in the group satiated for but 1 hour These expectations were confirmed As compared with the deprivation subjects the satiation subjects showed significant alterations in their incentive functions with greatly increased preference for 0 00 information series

ing significantly, which was interpreted as the result of the gradual dissipation of the satiation effects

The results of the Jones and McGill study appear to be consistent with the drive reduction reinforcement theory as exemplified by Hull (1952) and Miller (1951) Periods of information deprivation induce a drive process which motivates responses for stimuli of higher information value, stimuli which reduce the initially motivating condition of low stimulus information or information deprivation Conversely, periods of information satiation induce a drive process which motivates responses for stimuli of low information value, stimuli which reduce the initially motivating condition of information satiation The principal basis for asserting the existence of a drive process in the sense of the drive construct in contemporary reinforcement theory is the observation that increasing periods of the hypothesized noxious condition whether satiation or deprivation increasingly energizes response rates The assertion of the drive reducing function of high information stimuli for the information-deprived subjects and of low information stimuli for the information satiated subjects has two bases one logical and definitional the other empirical Logically since the information dimension of stimuli has been shown to be associated with drive processes the subjects exposure to stimuli which attenuate the objective operations resulting in drive must also reduce the internal energizing reactions Empirically the drive reducing function of exposure to the stimuli should be reflected in a cyclic character of response rate with periods of low response rate following periods of high response rate because of the temporary reduction of drive afforded by the high response rates and thus high rates of exposure to the stimuli (exposure or, more specifically, perceiving in the context of information drive being equivalent to eating in the context of the hunger drive) Cyclic phenomena of this sort have been demonstrated with regard to responses for high information under conditions of information deprivation in the data of two studies by Jones and his associates The original reports did not consider the cyclic character of response rate however and for this reason the reader is referred to a discussion in a more recent paper (Jones 1966) A parallel analysis of the cyclic character of response for low information stimuli under conditions of information satiation has not yet been completed

The demonstration of the homeostatic character of information drive occurred in the context of a single modality audition which characterized both the drive variable and the incentive variable High information auditory incentives appeared to reduce the drive associated with auditory information deprivation and low information auditory incentives to reduce the drive associated with auditory information satiation Extending the homeostatic principle still further we may question whether a condition of nonhomeostasis occurring in one modality may be "relieved" by

sociated with sensory deprivation The animal curiosity and exploratory studies in contrast, have been almost totally unconcerned with psychopathology but directed rather to general motivational principles The purpose of the review contained in this section is not to be comprehensive but rather illustrative of the animal findings regarding drive and incentive variables associated with perceptually restricted environments particularly those which may be seen to parallel the human studies already discussed Most of the animal studies in this area have been conducted with rats, a smaller number with monkeys, and they will be reviewed briefly here in that order

In the early 1950s the attention of several investigators was drawn to spontaneous alternation behavior in the rat behavior which was viewed as reflecting a motivation for stimulus change (e g Montgomery, 1952, Glanzer, 1953, Walker et al., 1955a, 1955b, Walker, Dember, Earl & Karoly, 1955) Direct tests of a drive process by manipulation of extent or temporal period of deprivation of stimulus variability were not a major focus of these studies The findings of Glanzer (1953), however, provide some data relevant to a drive hypothesis When rats confined in one arm of a T maze were subsequently permitted to choose between the arms, the tendency to choose the unfamiliar arm was greater after confinement of 15 to 30 minutes than after confinement of but 1 minute, a finding consistent with a drive interpretation of the animal s alternation behavior In an instrumental conditioning situation, Premack Collier, and Roberts (1957) permitted the subjects to respond for weak light-onset following 12 24, and 48 hours of prior light deprivation Response rate was an increasing function of hours of deprivation, thus supporting a drive interpretation of the visual deprivation condition

Fowler (1968) has recently reported a series of experiments addressed to the drive and incentive phenomena related to stimulus change under deprivation conditions of very brief duration In the first experiment, independent subject groups were confined in the black start box of a straight alley maze for 1, 3 or 7 minutes following which they were allowed to run to the goal box the sides of which were painted white Running speeds were a significant increasing function of the length of confinement, which was interpreted as evidence of a drive process Further support for a drive interpretation was provided by a second experiment which replicated the comparison of the 3 and 7 minute confinement groups A third study demonstrated that asymptotic running speeds under high and low-drive conditions showed the expected shift upward or downward when the drive conditions are reversed and that extinction occurs when the stimulus-change incentive is withheld by removing the white walls of the goal compartment and replacing them with black walls similar to those of the start box

In the second of Fowler's experiments, the magnitude of stimulus change was also manipulated All subjects ran from black start boxes to goal compartments which were black, gray, or white Running speeds were a significant increasing function of degree of stimulus change between start and goal compartments thus providing support for an incentive-motivational interpretation of stimulus change

Of the statistical dimensions of stimuli considered earlier—information, complexity, and fluctuation—the stimulus change for which Fowler's subjects responded conforms most closely to fluctuation, the stimuli of the goal compartment were neither unpredictable nor random but simply represented a change in stimulus category (e g , black to white) Similarly unidimensional manipulations of stimulus change were employed by Dember and Millbrook (1956), whose subjects selected the arm of a Y maze which showed the greater stimulus change over the range black-gray white, and by Levin and Forgays (1959), whose subjects showed a response rate that increased over increasing intensities of light incentives Other investigators have employed incentive variables in which the dimensions of information, complexity and fluctuation each appear to be involved but in relative degrees not readily established Several investigators have reported that rats spend more time investigating that portion of a previously familiar maze into which various novel stimulus objects are placed (Williams & Kuchta, 1957, Berlyne, 1950 Berlyne & Slater, 1957), and Zimbardo and Miller (1958) have shown that when the speed of rats running from one to the other compartment of a shuttle box has stabilized the introduction of such novel objects as springs bells and hollow cans produces a reliable increment in subsequent running speed That the introduction of such objects constituted a change of stimuli seems clear; but it would be difficult to determine what proportions if any, of the incentive value of the objects were due to their complexity, or degree of randomness along various physical dimensions and to their information, or degree of unpredictability

In contrast to many of the human stimulus seeking studies, each of the above rat studies has employed discrete incentives contingent upon the subject s single response In order to pursue phyletic comparisons of such motivational phenomena, it would be necessary to establish first the ability of particular species to discriminate the various statistical attributes of stimuli With regard to incentives consisting of series of stimuli, the only available evidence of which the author is aware indicates that for rats the discrimination of visual stimulus information is very difficult or impossible Thornton (1963) attempted to train rats to respond for food rewards upon presentation of a series of positionally varied (left and right side of Skinner box) light flashes of 1 00 information value, the control series consisted of the single alternation of light categories (0 00 informa

tion) None of the subjects showed evidence of acquiring the discrimination over the course of several hundred trials

Data concerning a drive interpretation of deprived visual experience have been provided at the monkey level by Butler (1957) and by Fox (1964) In Butler s experiment rhesus monkeys confined in a small box were allowed to make responses which opened a small window through which they could peer out Their response for such visual exploration increased significantly as a function of the number of hours of prior deprivation over the range zero to 4 hours These results are consistent with a drive interpretation of the visual restrictions associated with confinement but not conclusive because of the possibility that the increments in response were due principally or entirely to a manipulatory rather than to a perceptual-exploratory motive The more recent study of Fox (1964) provides a control for that possibility Fox maintained four rhesus and four *Macaca nemestrina* monkeys in totally visually deprived environments for 1, 2 3 and 4 hours before allowing them to determine the amounts of time during which programming apparatus would present series of brief (0 50 sec) light flashes The animals preference for stimulation (as opposed to no stimulation) increased significantly ($p <$ 001) as a function of hours of prior deprivation The subjects were allowed to choose between light series of maximal information regarding temporal occurrence which were characterized by interstimulus intervals randomly varied between 0 and 4 sec and series of zero temporal information which consisted of flashes at a constant interval of 2 sec (A third series beyond the scope of this discussion, consisted of the subject s own pattern of bar pressing for light incentives as established on a previous occasion) The subjects showed a significantly greater ($p <$ 001) preference for the maximal information series than for the zero information series Thus the drive inferable from the increased preference for stimulation over increasing hours of deprivation is clearly of a perceptual rather than a manipulatory activity since the manipulatory activity represented in the preference for each series was the same As the amount of sensation and mean number of light flashes were the same for both stimulus series it is clear also that the animals were responding for something more than the simple stimulus change of light-off to light-on Whether the subjects were responding for the informational (or unpredictable) aspect of the stimulus series or for a statistically subordinate attribute such as the complexity (or objective randomness) of the intervals is however not discernible from the study

In summary it appears reasonably well established that visual deprivation in rats generates a drive and that simple unidimensional stimulus change is associated with incentive properties which are directly related to the magnitude of the change There does not appear to be any evidence concerning the ability of rats to discriminate such higher-order attributes of stimuli as complexity and information Visual deprivation

generates a drive also in monkeys a drive which appears to be related to something other than an attribute of simple stimulus change As in the case of rats however, evidence concerning the ability of monkeys to discriminate stimulus complexity and stimulus information is lacking The seemingly clear evidence in support of an information drive at the human level, and the absence of evidence at the animal level, suggest the desirability of comparative, phyletic studies of both the discrimination and motivational phenomena associated with the statistical properties of stimuli

CONCLUSIONS

On the basis of evidence presently available the following generalizations appear tenable

Human motivation for meaningful sensory rewards

1 Sensory deprivation induces motivation for such meaningful sensory rewards as taped propaganda lectures and segments of stock market reports
2 Response for meaningful sensory rewards is not accountable for by such irrelevant drive factors as anxiety associated with nondeprivation features of experimentation but appears to be related directly to the sensory and perceptual restrictions
3 Evidence has not yet been presented that the motivation for meaningful sensory rewards satisfies the definitional requirements of the drive construct
4 Also the dimensions or attributes of the meaningful sensory rewards which are motivationally relevant have not been established

Human motivation for nonmeaningful sensory rewards

1 Deprivation of stimulus information is associated with a drive variable while deprivation of stimulus complexity and fluctuation does not result in evidence of a drive
2. Stimulus information and stimulus fluctuation constitute independent incentive dimensions but no incentive dimension is associated with stimulus complexity the apparent incentive properties of complexity being entirely reducible to those of the statistically subordinate dimension fluctuation
3 Stimuli which are entirely nonvariable—e g pure tones of brief duration—appear to serve minimally or not at all as rewards for instrumental activity except in the case of electrical stimuli associated with anxiety and pain
4 The information drive and incentive phenomena noted are not limited to a single modality but are demonstrable separately in the visual and auditory senses Demonstrations in other modalities have not yet been reported
5 The drive for stimulus information is not specific to the sensory system deprived of information but is a central process to which the information transmission of other modalities contributes Therefore for example the response rate for visual information in previously visually-deprived subjects is reduced if the visual deprivation was accompanied by exposure to auditory stimuli of high information value

6 Information drive is homeostatic in the sense that both relatively high and relatively low levels of stimulus information induce drive states which motivate responses serving to maintain some intermediate level of information transmission

Animal motivation for sensory rewards

1 No animal studies have been reported which give unequivocal evidence of a drive for stimulus information or stimulus complexity, although the possibility has been raised in monkeys which responded to visual incentives with increasing frequency as a function of hours of prior deprivation thus providing evidence of a drive variable They demonstrated, further, a preference for series of high temporal information over low temporal information, indicating that the motivationally relevant dimension was of a higher order statistically than the simple onset and termination of discrete signals, although whether it was the information dimension *per se* or the subordinate dimensions of complexity or fluctuation could not be established

2 Visual deprivation in rats is associated with a drive which motivates instrumental response for simple onset and termination of discrete signals Although drives may exist which are related to the statistical character of series of stimuli, rather than to single, discrete stimuli no evidence of such has been reported as yet in the rat as it has been at both the monkey and human levels

7

Sensory and Perceptual-Motor Effects

John P. Zubek

In a review of the literature on sensory and perceptual deprivation Kubzansky (1961b) stated that the studies are uneven in quality and range from carefully designed and executed procedures to vaguely formulated poorly controlled observations with small samples Similarly measurement in these studies has varied from precise psychophysical calibration to loosely defined clinical judgments unchecked for reliability (p 58–59) Although this assertion may be valid for a number of areas of investigation it is not applicable to most of the research on sensory and perceptual motor effects which in general has been characterized by a high level of sophistication in experimental design and precision in measurement Not surprisingly this research has also produced some of the most uniform and consistent results to be found anywhere in the isolation literature Contradictory findings have been reported as might be expected but these largely occur in studies involving qualitative rather than quantitative observations

For organizational purposes the review of the literature will be presented under two main headings The first multimodality deprivation will be concerned with the sensory and perceptual motor effects resulting *from an overall reduction in stimulation from several sense modalities.* The second section will consist of a description of the more recent research on single modality deprivation The material will further be subdivided on the basis of type of performance being appraised e g color perception depth perception etc. Although this form of organizational structure possesses many advantages particularly of clarity it does possess one limitation viz a repetition of the same experiment on a number of occasions since several different measures are frequently employed in a particular study

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In describing the various studies a differentiation will be made between sensory and perceptual deprivation, as defined in chapter 2 The employment of this twofold classification (Kubzansky, 1961b), rather than a single more general category such as stimulus deprivation possesses the merit of frequently being able to reconcile results which seemingly are contradictory in nature

MULTIMODALITY DEPRIVATION

Qualitative Reports of Perceptual Changes

McGill experiments One of the dramatic findings of the McGill studies was the presence of gross disturbances of the perceptual field Upon termination of 2 to 3 days of perceptual deprivation, the subjects frequently experienced difficulty in focusing objects appeared fuzzy and did not stand out from their backgrounds, there was a tendency for the environment to appear two dimensional and colors seemed more saturated than usual These disturbances in visual perception lasted for 1 or 2 minutes In addition the subjects also reported feelings of confusion, headaches a mild nausea and fatigue—phenomena which, in some cases, persisted for 24 hours after emerging from isolation (Bexton, Heron, & Scott, 1954)

In a subsequent experiment (Doane, Mahatoo, Heron, & Scott, 1959) a more detailed analysis was made of these unusual perceptual changes and the phenomena were classified into four main categories, viz, (1) *spontaneous movements*—includes all apparent activity of the visual field when the observer (including his eyes) was still, shimmering or undulation of surfaces and drifting, contraction or expansion of objects, (2) *induced movements*—refers to changes in the position of objects produced by head and eye movements, (3) *surface distortions*—refers to cases in which plane surfaces were described as warped, concave, or convex, or in which a convex swelling of the central part of the visual field was reported, and (4) *linear distortions*—which were appraised by two types of 'lines tests, viz, a horizontal line with a fixation point above and below the center of the line and two parallel vertical black lines with a fixation point in the center The distortions were characterized by various curvatures of the lines near the fixation point Furthermore these linear effects were quite pronounced, e g, 'the centers of the parallel lines might be displaced by one inch or more (p 213) Table 7–1 shows the incidence of the four types of phenomena in a group of 20 subjects Note that most of the subjects experienced these phenomena

In addition to these perceptual distortions there were reports of exaggerated contrast, hypersaturation and luminosity of colors, pronounced positive and negative after images accentuated or diminished depth of perception and distortions of human faces All of the effects

TABLE 7-1. Incidence of Various Disturbances of Visual Perception Immediately on Coming Out Of Isolation Qualitative Observations by 20 Subjects

Spontaneous *Movements*	Induced *Movements*	Surface *Distortions*	Linear *Distortions*
18	12	16	18

SOURCE Reprinted by permission of Univer of Toronto Press from B K. Doane, W Mahatoo, W. Heron, & T. H Scott, *Canad J Psychol*, 1959, 13, 210-219

described were obtained with both monocular and binocular vision, but were more marked binocularly (p 213) These effects usually disappeared in about half an hour It is important to note that these unusual perceptual changes were observed not only in the isolated subjects but also in three of the four ambulatory subjects who wore translucent goggles for 3 days but were never confined in the isolation cubicle 'They were worked with in pairs, and allowed to talk with each other, to listen to the radio, to go for walks, and, in general, to engage in as much normal activity as was possible in the circumstances' (p 210) The results derived from these ambulatory subjects appear to indicate that visual deprivation alone is sufficient to produce a variety of distortions and changes in the perceptual field

In order to further investigate these qualitative changes in visual perception Heron, Doane, and Scott (1956) served as subjects themselves for 6 days of perceptual deprivation They described the disturbances in visual perception as "unexpectedly profound and prolonged," effects which, in general, were the same for all three observers Although their experiences were similar to those reported in the shorter duration experiments, they were of much greater magnitude, e g, "the wall bulged towards me and went back, the experimenter looked short, then he suddenly got taller, then he closed up again, the whole room is undulating swirling, things don't stay put, people appear rouged" Some of these distortions were still present 24 hours later, in all three subjects

Research at other laboratories Although many of the McGill results have been confirmed in subsequent research at other laboratories, their qualitative data on gross perceptual changes has not, with several exceptions, been replicated For example, Vernon and Hoffman (1956) questioned four subjects after 2 days of sensory deprivation, specifically about difficulty in focusing, increased saturation of colors and lack of three dimensional perception and reported negative findings for all three phenomena Numerous other investigators have also failed to observe these

gross perceptual changes regardless of the duration or type of deprivation employed e g 8 hours of perceptual deprivation (Schwitzgebel 1962) 2 days of perceptual deprivation (Arnhoff Leon & Brownfield 1962), 3 and 4 days of sensory deprivation (Myers Murphy Smith & Goffard 1966) 4 hours to 7 days of sensory deprivation (Ruff & Levy 1959, Levy, Ruff, & Thaler 1959) and perceptual deprivation for as long as you can take it (Smith & Lewty 1959)

Negative results have also been reported from the Manitoba laboratory after a week of either sensory (Zubek Pushkar Sansom & Gowing 1961) or perceptual deprivation (Zubek et al 1962) Furthermore no gross qualitative changes of a perceptual nature have been reported even after 14 days of perceptual deprivation (Zubek, 1964a Zubek Welch & Saunders 1963) or after 7 days of perceptual deprivation with no test intrusions and no communication with the subject (Zubek 1964b)

In several of the Manitoba 7-day experiments a lines test identical to that employed at McGill was used to determine linear distortions Approximately half of the experimental subjects reported some distortions but these were barely noticeable and were characterized by a *very slight* wavering thickening or change in apparent length of lines However, since these phenomena were also reported by the same proportion of recumbent and ambulatory control subjects tested before and after a 1 week period they cannot be attributed to perceptual deprivation Some of the experimental subjects also commented on a lack of depth perception and on the brightness and vividness of colors of objects and surfaces in the external world outside the laboratory It is interesting to note that similar experiences were mentioned by almost the same percentage of non isolated recumbent controls who during the course of the week were not permitted to look out of the windows at the outside world although they could read watch television and listen to a radio These results suggest that at least some of the postisolation qualitative changes reported at the McGill laboratory may simply have resulted from the forgetting of the actual appearance of the external perceptual environment as a result of prolonged removal from it

In addition to these studies numerous others of varying duration could be cited in which no specific mention is made of the presence of post isolation perceptual distortions If they had occurred to any noticeable degree they would undoubtedly have been reported

In conclusion three short duration experiments will be described in which perceptual distortions similar to those at McGill were reported In the first of these Freedman and Greenblatt (1959) employed three groups of ten subjects each viz sensory deprived perceptually deprived and socially isolated controls The subjects were tested before and after an 8 hour period for their perception of four simple figures placed at a dis-

tance of 12 ft a straight line a triangle a cross and three arrowheads They were asked to describe in detail the appearance of the figures and to draw the figures if they appeared distorted A great variety of distortions were reported by the experimental subjects e g triangles seemed to change shape straight lines appeared to move and bend halos developed and arrowheads most frequently seemed to graduate in size from left to right These effects persisted for 5 minutes or more A statistical analysis revealed that the incidence of distortions was significantly greater in both experimental groups relative to the controls with the incidence considerably greater after perceptual than after sensory deprivation

Similar results were reported in a subsequent study (Freedman Grunebaum & Greenblatt 1961) Courtney Davis and Solomon (1961) using a modification of the Freedman pattern test also reported that 16 out of 17 subjects experienced visual distortions similar to those mentioned earlier after only 4 hours of perceptual deprivation Contrary results however were reported by Zubek (1961b) who administered the identical Freedman pattern test to a group of subjects before and after 7 days of perceptual deprivation Only two of the 16 subjects reported any visual distortions This discrepancy in results between the effects of short term and long term perceptual deprivation on the same measures is puzzling Perhaps these particular types of visual distortions only occur after a brief period of deprivation Another possibility is that they are a suggestion phenomenon arising from the test instructions or other procedural variables This certainly seems a possibility at least in the Courtney study in which the subjects were informed that you will be paid a bonus for how well you relate your thoughts of how you feel and for describing in detail anything unusual that you see hear or feel (p 193) This promise of a *bonus* may have led to a free reign of their imagination

The weight of the experimental evidence clearly indicates that conditions of reduced sensory input do not produce a variety of dramatic and unusual disturbances of the perceptual environment as reported initially from the McGill laboratory—at least as derived from the qualitative observations Furthermore these effects appear to be absent regardless of duration employment of prescribed or indeterminate durations, presence or absence of test intrusions and type of deprivation condition employed Although it has been demonstrated that numerous variables can influence the results of deprivation experiments (see chapter 3) it is doubtful whether the operation of any one variable can account for the discrepancy between the McGill results and those at almost all other laboratories A more likely possibility is that the unusual McGill phenomena were produced by some unique interaction of several variables of a procedural personal or motivational nature

Visual Measures

In addition to appraising qualitative perceptual changes, a large variety of objective measures of visual perception were administered at the McGill laboratory before and after several days of perceptual deprivation (Bexton, Heron, & Scott, 1954, Heron Doane, & Scott, 1956, Doane, Mahatoo Heron, & Scott, 1959, Scott, Bexton, Heron, & Doane, 1959) The measures which revealed a significant impairment included the Gottschaldt Embedded Figures size constancy, color adaptation, figural aftereffects, autokinetic effect Archimedes spiral aftereffect, and speed of copying a prose paragraph On the other hand no significant changes occurred on measures of c f f, phi phenomenon, brightness contrast brightness constancy, shape constancy, Necker cube reversals, tachistoscopic perception, and mirror drawing Finally, there was a strong suggestion of an *increase* in visual acuity

In contrast to the McGill findings on qualitative perceptual changes, some of their results derived from objective measures have been supported by subsequent research at other laboratories A review will now be presented of the literature dealing with a variety of specific measures of visual perceptual performance

Depth perception Although no objective measures of depth perception were employed at the McGill laboratory, many of their subjects commented on the two-dimensional nature of the environment An impairment of depth perception might therefore be predicted This prediction however, has not been confirmed in subsequent studies Freedman and Greenblatt (1959) using the Howard Dohlman apparatus, reported no changes in depth perception after 8 hours of either sensory or perceptual deprivation In a study employing the Bausch and Lomb Orthorater, Pollard Uhr, and Jackson (1963a) also reported no significant impairment of depth perception after a similar short period of perceptual deprivation A similar picture of negative results was also obtained at the Manitoba laboratory after a week of either sensory (Zubek, Pushkar, Sansom & Gowing 1961) or perceptual deprivation (Zubek et al, 1962) Furthermore, depth perception was not affected even after 14 days of perceptual deprivation (Zubek, 1964a) The Howard Dohlman apparatus was employed in all three Manitoba studies Further evidence for the finding that depth perception is impervious to even unusually long durations is provided in an animal study of Walk, Trychin and Karmel (1965) Rats visually deprived for periods up to 125 days were still able to discriminate depth using the visual cliff procedure It was only after durations of 110 days or longer that depth perception was adversely affected

Finally Vernon McGill Gulick and Candland (1961) investigated the effects of different durations of sensory deprivation upon the perception of depth No change was observed after either 2 or 3 days of deprivation

relative to control groups who were tested at the same time intervals Furthermore the scores of the experimentals and controls were almost identical However depth perception was adversely affected after 1 day of deprivation but because of large individual variations in scores the results only bordered on statistical significance Vernon interprets these results as indicating that short term deprivation has a more deleterious effect upon depth perception ability than does longer term confinement (p 52) This interpretation is questionable since both Freedman and Greenblatt (1959) and Pollard Uhr and Jackson (1963a) reported no disturbances of depth perception after an 8 hour period On the other hand it is possible that a critical period may exist between 8 and 24 hours during which the perception of depth is adversely affected

The constancies Doane Mahatoo Heron and Scott (1959) reported no changes in brightness and shape constancy but a significant decrease in size constancy in 17 subjects who were perceptually deprived for 3 days A similar impairment of size constancy was also reported in three subjects after 6 days of perceptual deprivation (Heron Doane & Scott 1956) Contrary results have been reported in a series of studies from the Manitoba laboratory Zubek Pushkar Sansom and Gowing (1961) reported no significant changes in size constancy in 16 subjects exposed to a week of sensory deprivation Negative results were also obtained in two subsequent experiments involving (1) 29 subjects undergoing a week of perceptual deprivation with periodic test intrusions (Zubek et al 1962) and (2) 12 subjects exposed to a week of perceptual deprivation but with no test intrusions and no subject experimenter communication (Zubek 1964b) Furthermore no significant changes in size constancy were observed in ten subjects even after 14 days of perceptual deprivation (Zubek 1964a) An analysis was also made of the performance of an additional group of 23 subjects from the four experiments all of whom had terminated isolation prematurely after a mean period of approximately 2 days These isolation quitters also evidenced no significant impairment of size constancy

Negative results have also been reported in two short term studies Both Schwitzgebel (1962) and Freedman and Greenblatt (1959) reported no significant changes in size constancy after 8 hours of either sensory or perceptual deprivation Thus the weight of the experimental evidence seems to suggest that various types of constancies appear to be immune to conditions of reduced sensory stimulation of both brief and long durations a finding also applicable to depth perception

Brightness and flicker discrimination A variety of measures of brightness discrimination appear to be unaffected by either short or prolonged periods of deprivation Doane Mahatoo Heron and Scott (1959) reported no changes in brightness contrast using the method of Thurstone after 3 days of perceptual deprivation Zubek (1964b) also observed

no changes in brightness discrimination after a week of perceptual deprivation. The task consisted of the matching of two illuminated panels on the basis of brightness. Finally, Batten (1961) reported no changes in brightness difference thresholds after an hour of perceptual deprivation.

Measures of critical flicker frequency (c.f.f.) have also been employed in a numher of laboratories. No changes in c.f.f. were observed by Doane, Mahatoo, Heron, and Scott (1959) after 3 days of perceptual deprivation and by Zubek (1964a) after 14 days of perceptual deprivation. Similar findings also apply to the effects of short-term deprivation. No significant effect on the c.f.f. was observed by Leiderman (1962) after 2 to 6 hours of perceptual deprivation.

Contrary results have been reported by the Japanese investigator Nagatsuka (1965). A significant decrease in c.f.f. occurred in ten subjects after 2 days of perceptual deprivation. A "pre-post" decrease of 1.70 cps was shown in contrast to an increase of 0.80 cps in a group of ten control subjects. Although these results appear to be at variance with those reported at other laboratories, they may in fact not be so. A duration of 2 days was employed which Vernon, McGill, Gulick, and Candland (1961) have shown produces a greater deficit than either shorter or longer durations on color perception, mirror drawing, and rotary pursuit task. In view of these results it is possible that c.f.f. is perhaps only affected by deprivation periods of medium duration.

Nagatsuka and Maruyama (1963) also investigated the changes in electrical flicker, using Motokawa's method, after 2 days of perceptual deprivation. Stimulating electrodes were placed at the outer corners of the eyes and the eyes were stimulated with rectangular pulses of 20 cps. The stimulating voltage was then increased until the first appearance of flicker and subsequently decreased until the flicker disappeared. The results revealed that the "value of electric flicker increased remarkably." The investigators interpret this effect as being due to the presence, during isolation, of certain "unfavorable conditions," such as fatigue, which are known to increase the value of electrical flicker.

Color perception. The evidence indicates that prolonged, but not short-term deprivation periods, can produce an impairment of color perception. Using a yellow color matching test, Doane, Mahatoo, Heron, and Scott (1959) observed a significant impairment of color matching in 13 subjects after 3 days of perceptual deprivation. Vernon, McGill, Gulick, and Candland (1961) administered the Dvorine Color Test to three groups of subjects who were sensory deprived for 1, 2, and 3 days. This test required the subject to identify numbers on the plates in the usual manner of color vision testing. Figure 7–1 shows that the color perception of all three experimental groups is poorer than that of controls tested at the same time intervals. Statistically, however, only the deficits shown by the 2- and 3-day groups were significant. An examination of the color plates missed

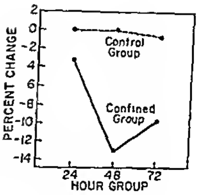

FIGURE 7–1 Color perception of the experimental and control subjects, per cent change from the pre to the postexperimental period

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showed that no particular color was consistently missed and that the failures occurred primarily for the desaturated hues

In Figure 7–1 it can also be seen that color perception is worse after 2 days than after either 1 or 3 days indicating a possible recovery of function or an adaptation effect after the second day Since a similar indication of recovery of function with increasing durations was also observed by Vernon on a mirror drawing and rotary pursuit task it would appear that differential results can occur depending upon the particular duration employed Differences in duration employed at various laboratories may therefore account for some of the contradictory results in the literature

Another measure of color perception the Farnsworth Munsell 100 Hue Test was administered by Zubek et al (1962) to a group of 29 subjects who endured a week of perceptual deprivation and to two groups of recumbent and ambulatory control subjects The color discrimination of the experimental subjects was significantly poorer than that of either control group Furthermore since there was no significant difference in the performance of the two types of control subjects these deficits on color perception cannot be attributed to the maintenance of the recumbent position An impairment of color discrimination was also observed in ten subjects who terminated isolation prematurely (mean duration = 55 hrs) Similar results were again obtained in a subsequent study (Zubek 1963a) in which the subjects were required to perform various physical exercises during a week of perceptual deprivation Apparently increasing the level of kinesthetic and proprioceptive stimulation during isolation is unable to counteract or minimize deficits in color perception

An interesting description of changes in visual perception has been presented by Siffre (1964) who spent 63 days living in darkness and silence in an underground cavern located 425 feet below the surface A comprehensive examination of various visual processes was made by an ophthalmologist before and for several weeks after emergence from the cavern Siffre reported that his color perception was seriously affected with green

being seen as blue Other changes were a disturbance of binocular vision, increase in myopia, intensification of a constitutional exophoria and intermittent strabismus, and a modification of the electroretinogram All of these effects persisted for more than a month after return to normal living conditions Although this is only a single case, the results, nevertheless, are suggestive, particularly since they indicate the presence of unusually long aftereffects

Finally, Pollard, Uhr, and Jackson (1963a) reported no significant changes in binocular color rivalry after 8 hours of perceptual deprivation These negative results may indicate that either this particular measure of color perception is not affected by deprivation or that the duration was too brief for the effects to occur The fact that Vernon, McGill, Gulick, and Candland (1961) reported no significant deficits in color perception after 1 day but did observe deficits with longer durations suggests that the shortness of the duration may be the critical variable

Tachistoscopic perception Doane, Mahatoo Heron, and Scott (1959) reported that a 3-day period of perceptual deprivation produced no changes in the tachistoscopic perception of a series of black nonsense forms (outlines) presented one at a time on a white screen for approximately 50 msec. A recognition method of testing was used The only other research on this topic are two studies employing very short durations Both of these have indicated an increase in visual sensitivity In the first of these (Rosenbaum Dobie & Cohen, 1959), recognition thresholds for a list of 13 five-digit numbers were obtained after deprivation periods of 0 5 15 and 30 minutes on 4 different days Two groups of 16 subjects each were used one exposed to sensory deprivation and the other to perceptual deprivation Prior to threshold determinations the subjects were allowed several minutes for adaptation to normal light The results were quite unexpected A lower visual recognition threshold for both conditions, occurred after 5 minutes of deprivation On the other hand, the 15- and 30-minute periods had no effect on the threshold but instead induced boredom and emotional states which the authors claim may have interfered with visual efficiency

An increase in visual efficiency after a brief period of deprivation has also been demonstrated by Friel and Derogatis (1965) A group of 18 subjects were asked to identify four letter nouns given at various exposure times, immediately after the termination of a 50-minute period of perceptual deprivation The results revealed that the experimental subjects could recognize significantly more words at a faster exposure time than could a nondeprived control group It is interesting to note that a somewhat similar facilitatory effect has been observed in monkeys following electrical stimulation of the reticular system According to Fuster (1958) these animals showed a faster reaction time and an improved performance on a visual discrimination task presented tachistoscopically a finding

which suggests that the human facilitatory effects may also be a reflection of reticular system activity

Perception of embedded figures Several groups of investigators have employed the Gottschaldt Embedded Figures or a modification of them in which the subject is asked to locate a simple geometrical design which he had previously seen within a complex geometrical design The evidence indicates that this measure is adversely affected but only by prolonged deprivation periods Scott Bexton Heron and Doane (1959) reported a significantly poorer perception of the Gottschaldt figures after several days of perceptual deprivation This deficit however does not appear if social isolation alone of 2 days duration is employed (Ormiston & Finkelstein 1961)

As far as the effects of short term deprivation are concerned all of the evidence clearly indicates an absence of a perceptual deficit on the Gottschaldt figures No significant changes have been observed after 2 hours (Culver Cohen Silverman & Schmavonian 1964) 2 to 6 hours (Leiderman 1962) or 8 hours of perceptual deprivation (Schwitzgebel 1962) This last study interestingly employed a group of South African Zulus as well as English speaking whites

Bender Gestalt Test This test which has frequently been used by clinical psychologists in the differential diagnosis of brain damage consists in exposing a subject to a set of cards and asking him to copy each of them as accurately as he can Various methods can then be employed to appraise any changes in the form quality of the Bender Gestalt reproduction An extensive use of this test has recently been made in three Japanese studies all employing the Pascal method of scoring In the first (Harm & Uenn 1961) nine figures were presented to a group of 11 subjects immediately after 2 days of perceptual deprivation The figures were presented until all of the subjects could complete their copying The results revealed a significant deterioration in the form quality of the figures in relation to a group of control subjects In the second study (Ueno & Tada 1965a) three modifications were introduced viz 1 day of perceptual deprivation a delay of an hour before test administration and use of a series of brief exposure periods ranging from 5 to 200 msec rather than an unlimited exposure of the Bender Gestalt figures No significant differences between the experimental and control subjects were found for any of the different exposure periods In view of the presence of three major procedural differences it is impossible to specify which of them are responsible for the negative results

In the third study (Ueno & Tada 1965b) two further modifications were introduced viz an 18 hour period of perceptual deprivation and exposure durations ranging from 200 msec to 51 2 seconds Furthermore in one group of subjects the test was administered immediately after deprivation whereas in the other group it was delayed for an hour The

results revealed no significant changes in form quality when the Bender Gestalt was delayed for an hour. On the other hand, a significant deterioration did occur when the test was administered immediately after deprivation but only with exposure periods of medium duration. One fact clearly emerges from these Japanese experiments, viz., the importance of time of test administration.

Changes in Bender Gestalt reproduction have also been studied in several short-term deprivation experiments. Freedman and Greenblatt (1959) reported the presence of a poorer form quality in both perceptually and sensory deprived subjects when the Bender Gestalt was administered immediately after 8 hours of deprivation. On the other hand, Reitman and Cleveland (1964) and Cleveland, Reitman, and Bentinck (1963) observed no changes in form quality after 4 hours of perceptual deprivation. However, in both studies a lengthy battery of tests was employed and, if the Bender Gestalt happened to be administered late in the series, as appears to be the case, no changes would be expected.

These results appear to indicate that a significant deterioration in the form quality of the Bender Gestalt can occur after both short and prolonged periods of deprivation but only if the test is administered immediately after the termination of isolation.

Visual illusions. A wide variety of illusory phenomena have been investigated. One of the most popular has been the autokinetic phenomenon in which the subject has to watch a pinpoint source of light in a dark field. Unfortunately, the results are inconsistent. Doane, Mahatoo, Heron, and Scott (1959) observed no change in the latency of onset of the autokinetic movement after 3 days of perceptual deprivation. However, when the level of illumination of the visual field was gradually increased, the movement persisted through higher levels of surrounding brightness. Zubek (1964b), on the other hand, reported that the latency of onset after a week of perceptual deprivation was approximately twice as long as that shown prior to isolation. No significant pre-post differences in latency were shown by the control subjects tested over the same interval. In the only other long-duration experiment, Walters, Callagan, and Newman (1963) reported no changes in latency of onset in penitentiary inmates socially isolated for 4 days.

Inconsistent results have also been obtained in two short-term deprivation experiments. In the first, Ormiston (1961) reported no significant differences in the latency of the autokinetic effect before and after 8 hours of perceptual deprivation or in relation to control subjects tested at the same time intervals. In the second study, Walters and Quinn (1960) used four groups of subjects who were exposed to 30 minutes of combined social and sensory deprivation, sensory deprivation, social deprivation, and a control group involving no deprivation. The results revealed that the latency of response was *shortest* for subjects who had experienced both

social and sensory deprivation intermediate for those who had experienced social deprivation only or sensory deprivation only and longest for those who were used as control subjects The *finding that 30 minutes of* social deprivation should significantly change the latency of the autokinetic movement is surprising because in another study, by Walters Callagan and Newman (1963) a 4 day period of social deprivation was shown to have no effect

Thus no consistent pattern of changes in the autokinetic effect seems to occur after either brief or prolonged deprivation periods with increases decreases or no change in latency of response being reported The presence of these random like results is perhaps not too surprising because it is known that a variety of psychological variables such as expectancies set and attitudes can easily influence this phenomenon The differential operation of these variables at the various laboratories may have yielded this inconsistent set of results

In contrast to the results on the autokinetic effect the experimental evidence clearly indicates an increase in the duration of the spiral after effect (Archimedes spiral) after both long and short periods of deprivation This was demonstrated by Doane Mahatoo Heron and Scott (1959) after 3 days of perceptual deprivation and by Ormiston (1961) after 8 hours of perceptual deprivation An increase in duration of the aftereffect was also reported by Suzuki Fujii and Onizawa (1965) when the Archimedes spiral was administered *immediately* after 18 hours of perceptual deprivation However no significant effect occurred in another group of subjects who were tested 1 hour after termination of perceptual deprivation The time of test administration therefore appears to be a critical variable a finding consistent with the Doane Mahatoo Heron and Scott (1959) statement that tests of perception have to be completed in a short time since the major effects seem to wear off in an hour or two (p 211) A lack of sufficient attention to this variable in much of the isolation literature may account for some of the contradictory results e.g., in the research on the autokinetic effect

Another type of apparent movement which has been investigated is the phi phenomenon in which movement occurs when two stimuli are presented in a certain temporal and spatial order Doane and co-workers reported that after 3 days of perceptual deprivation no changes were observed in the timing of the stimuli which gave rise to apparent movement Contrary results were reported by Nagatsuka and Maruyama (1963) who found that the threshold of apparent movement was heightened after 2 days of perceptual deprivation in comparison with almost consistent values in the control experiment

In addition to these studies on the phi phenomenon two experiments have been concerned with the effects of brief deprivation periods In the first Ormiston (1958) compared 30 minutes of perceptual deprivation

sensory bombardment, and a control condition on the perception of the phi phenomenon with 30 subjects serving in each condition In the sensory bombardment condition the subjects were exposed to motor tasks, a tape recording of various sound effects taste and smell stimuli, and a variety of colored goggles The perceptually deprived group showed a significant increase in the perception of phi whereas the sensory bombardment group showed a trend toward a decrease in phi perception The control group showed no change In a subsequent experiment Ormiston (1961) compared the effects of 8 hours of perceptual deprivation with a similar period of a control condition No significant effect was observed although the results bordered on statistical significance These negative results probably can be attributed to an insufficient reduction of sensory stimulation Although the subjects were exposed to auditory deprivation, they wore no translucent goggles but were merely confined in a windowless, gray painted cubicle

Although certain inconsistencies exist the experimental evidence does suggest that an impairment of phi perception probably can occur after both short and long deprivation periods

The magnitude of the Muller Lyer illusion has been studied at two laboratories Suzuki, Fujii and Onizawa (1965) reported a significant decrease in the magnitude of the illusion when it was presented immediately after the termination of 18 hours of perceptual deprivation No change was observed in another group of subjects who received the test an hour after emerging from isolation Freedman and Greenblatt (1959) on the other hand, observed no significant changes in the Muller Lyer illusion after 8 hours of either sensory or perceptual deprivation It is important to note however, that a lengthy battery of tests was administered with the Muller Lyer illusion *always* being presented in the middle of the series In view of the results of Suzuki and co-workers it is probable that a significant change would have occurred if the illusion had been presented immediately after deprivation

Another illusion that has received some attention is the perception of reversible figures (Necker cubes) The results from the McGill laboratory indicated no change in the frequency of reversals after a 3-day period of perceptual deprivation (Doane Mahatoo Heron, & Scott 1959) Contrary findings were obtained at the Manitoba laboratory viz a significantly slower frequency of reversals per minute after a week of perceptual deprivation (Zubek et al 1962) No significant changes were shown by either ambulatory or recumbent control subjects In another study employing a week of sensory deprivation a slower reversal rate was again observed but the result was not statistically significant (Zubek, Pushkar Sansom & Gowing 1961) This apparent discrepancy in the effects of perceptual deprivation observed at these two laboratories can probably be attributed to differences in time of test administration At the Manitoba laboratory the figures were presented almost immediately after dep-

rivation whereas at McGill they were always presented in the eleventh position of a 2 hour battery of 13 tests

Changes in reversible figures can also occur after short term deprivation periods but only under certain specific conditions Leiderman (1962) observed no changes in Necker cube reversals after 2 to 6 hours of perceptual deprivation a finding which he feels may be explained partly by the delay of 20 minutes in test administration whereas Ormiston (1961) reported a slower frequency after 8 hours of perceptual deprivation Freedman and Greenblatt (1959) also using an 8 hour period and the Two-Faces Vase illusion in addition to the Necker cubes reported that sensory deprivation had no significant effect on either illusion a finding similar to that of Zubek Pushkar Sansom and Gowing (1961) The effects of perceptual deprivation however were differential The frequency of Necker cube reversals was decreased significantly supporting the perceptual deprivation results of Ormiston (1961) and Zubek et al (1962) whereas the Two-Faces Vase illusion surprisingly revealed a significantly *faster* rate of alternation on the postisolation test No changes were shown by control subjects on either of the two figures In discussing these differential results the investigators stated that if these results are valid then tests with the two figures are simply not measuring the same effect Phenomenologically the two figures are different and the spontaneous tendency to alternation was much greater for the Two Faces-Vase figure as indicated by the generally faster rates reported (p 16) Clearly further research is indicated

In summary it appears that an impairment of reversible figures can occur with the specific results being dependent upon such variables as type of deprivation time of test administration and the nature of reversible figures employed

Finally a brief mention will be made of the scanty literature on figural aftereffects In the only long-duration experiment which studied this phenomenon Doane Mahatoo Heron and Scott (1959) observed an increase in the magnitude of the visual figural aftereffect The inspection and test patterns of Kohler and Wallach s Figure 36 were employed It is interesting to note that this positive finding was demonstrated by test administration within a few minutes after the termination of perceptual deprivation Changes in the magnitude of both visual and kinesthetic aftereffects were also observed by the Italian investigators Canestrari Bonaiuto and Umilta (1964) after short term sensory deprivation The direction of change however was toward a decrease in magnitude No further details can be provided because the reference was available only in abstract form

Perceptual lag An unusual phenomenon observed by one of the McGill 6-day subjects was an *S* shaped appearance of a straight black line slowly rotating against a dimly illuminated screen This perceptual distortion was attributed to an induced perceptual lag —the ends of the

line lagging behind the center (Heron, Doane, & Scott, 1956) This incidental observation has led to several investigations of this phenomenon In an exploratory study, Freedman and Greenblatt (1959) reported no distortion in the shape of the slowly rotating line, after 8 hours of perceptual deprivation but did note a significant reduction in the apparent speed of the line A similar duration of sensory deprivation or of a control condition produced no such change in apparent speed In a second exploratory study, also employing 8 hours of perceptual deprivation, Held and White (1959) also found no evidence for a perceived distortion of the line but did observe a 16 percent reduction in the apparent speed of the sweeping line All experimental subjects experienced the effects

Further work on this phenomenon was undertaken by Freedman and Held (1960) who used a 3-hour duration of deprivation and three experimental conditions One condition (Diffuse) involved perceptual deprivation with a homogeneous unpatterned visual field, another employed sensory deprivation (Blackout), and the third was referred to as the Random Flash condition The subjects in this last group were required to view, through translucent goggles, a display of three incandescent lamps set in a row 6 inches apart and 2 feet above the eyes The lamps flashed at different rates durations and interflash intervals This unusual condition was used to test the hypothesis that "dominance of the visual system for long periods by intrinsic noise (spontaneous retinal activity occurring during homogeneous stimulation) may result in reduction of apparent speed and therefore even greater reduction should result from exposing observers to a barrage of randomized visual stimulation—extrinsic noise" (p 277) The perceptual lag test was administered before and then during each of the three experimental conditions at intervals of 30 minutes

The results are summarized in Figure 7–2 It can be seen that a reduction in apparent speed of the moving line occurs after all three experimental conditions Furthermore, as had been predicted, the Random Flash condition produced a greater effect for each time period measured, rising to a maximum of −40 percent, whereas for the Blackout and Diffuse conditions maxima were at approximately −23 and −17 percent, respectively These Random Flash effects were significantly greater than those produced by the other two conditions at all time intervals except 150 minutes The differences between the Blackout and Diffuse scores were not significant There was however, a trend toward a greater reduction in apparent speed for the Blackout condition which may be related to the fact that spontaneous retinal unit firing is somewhat greater in the dark adapted than in the light adapted eye (Granit 1955 Kuffler 1953) Upon termination of the 3-hour experimental period the subjects tended to return slowly to normal speed perception Five out of seven retested a half hour later showed appreciable but not a complete return to the baseline level two remained at about the same level (p 279)

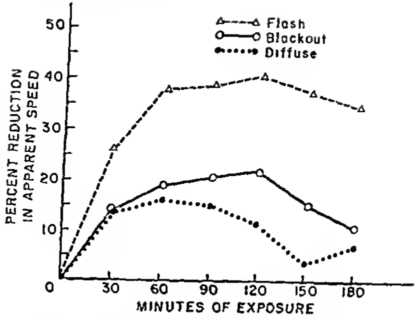

FIGURE 7–2 Changes in perceptual lag under three different exposure conditions

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A significant reduction in the apparent speed of a moving line was also reported by Pollard Uhr and Jackson (1963a) after 8 hours of perceptual deprivation This perceptual lag phenomena interestingly was also present after a second deprivation period a week later Prior deprivation experience therefore does not appear to influence this phenomenon

Visual reaction time Significant decreases in speed of reaction time to a visual stimulus can occur after both prolonged and short deprivation periods Nagatsuka and Suzuki (1964) administered three types of reaction time tests before and immediately after 2 days of perceptual deprivation simple reaction time in which the subject released a key at the appearance of a yellow light choice reaction A consisting of three different stimuli (green yellow and red) presented successively in the same place and choice reaction B in which the three lights appeared in a row On both the simple and choice reaction A measures the deprived subjects reacted more slowly in relation to a control group Surprisingly no significant change occurred on choice reaction B which the investigators attribute to differential experience i e the control subjects had experienced choice reaction B before but the experimental group had not (p 67) In another study from the same Japanese laboratory Nagatsuka and Maruyama (1963) employed a somewhat different measure referred to as a speed anticipation reaction test in which a small light patch moved behind a

black screen at a constant speed The subject's task was to press a key as soon as he thought the patch would emerge from behind the screen The results revealed a significant increase in anticipation time after a 2-day deprivation period

The only other long term deprivation study, appraising visual reaction time, was performed at the Princeton laboratory (Vernon, 1963) A group of 15 subjects were sensory deprived for a prescribed period of 4 days Of these subjects only seven endured the 4-day period The results derived from the total sample revealed no change in simple visual reaction time This finding, however, was only half correct A further analysis of the data revealed that whereas the seven successful subjects showed no change in reaction time, the eight isolation 'quitters" showed a significantly slower reaction time after sensory deprivation Apparently the two sets of results tended to cancel each other thereby giving a spurious picture of the performance of the whole group Because a similar differential picture was also observed by Vernon on hand tremor, a cognizance of this fact is required in future investigation in this area Unfortunately, in the past this variable has rarely been considered

Although it would appear from Vernon's results that successful and unsuccessful subjects react differently to isolation, this may in fact not be the case The critical factor may be a shorter deprivation period rather than 'quitting In an earlier paper, Vernon McGill, Gulick, and Candland (1961) reported that a 2-day deprivation period produced a greater deficit than either shorter or longer durations on measures of color perception mirror drawing and rotary pursuit If his isolation "quitters" therefore, terminated the condition at approximately the second day, which presumably they did, a slower reaction time might be expected This interpretation may also account for another set of data, viz, no change in reaction time in Vernon s 4-day successful subjects and a significant slowing in the Japanese 2-day experiments, all of whose subjects incidentally were successful endurers

In one of the two short term deprivation studies that have been performed, Leiderman (1962) observed no significant changes in simple and choice reaction time after 2 to 6 hours of perceptual deprivation Because the test administration was delayed for 20 minutes, an absence of a significant effect might be expected Supporting evidence for this interpretation is provided by the Russian investigator Kamchatnov (1962a) who reported a significant slowing of simple reaction time on a test administered immediately after 8 hours of darkness but with normal auditory stimulation These results are of considerable significance because they indicate that certain perceptual measures can be affected by visual deprivation alone—an overall reduction in sensory input from several modalities is not essential Further evidence for this finding will be presented in a later section

Other visual measures Subjects who have been exposed to a prolonged period of isolation frequently appear dull sluggish, and not very alert This would suggest that objective measures of visual vigilance might reveal a poorer state of alertness particularly because it has just been shown that isolated subjects show a slower visual reaction time A demonstration of a decrease in visual alertness has been provided in two studies from the Manitoba laboratory In the first 16 subjects were tested before and after a week of sensory deprivation (Zubek Pushkar, Sansom & Gowing 1961) The apparatus consisted of an electric laboratory clock (8 in in diameter) with a single rotating hand which was briefly stopped and then started at eight irregular time intervals during each of four successive 30-minute intervals The subject s task was to indicate the presence of a signal by pressing a key The results are shown in Figure 7–3 It can be seen that the experimental and control subjects show the classic vigilance decrement curve with increasing intervals of ' time on watch both before and after the 1 week period However, after deprivation the vigilance performance of the experimentals is much poorer than that of the controls at all four time periods It is interesting to note that although the vigilance performance of the controls has levelled off during the last 60 minutes it is still deteriorating in the experimentals

In a subsequent 1 week experiment Zubek et al (1962) employed a condition of perceptual deprivation and for comparative purposes two groups of ambulatory and recumbent control subjects A decrement in

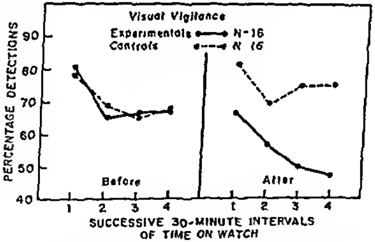

FIGURE 7–3 Performance of experimental and control subjects on a visual vigilance task in terms of percentage detection of signal changes occurring in four successive 30 minute intervals of time

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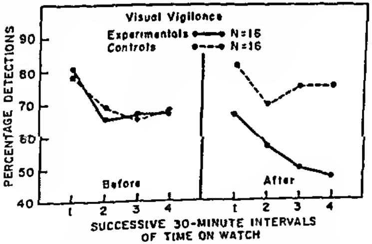

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vigilance performance again occurred with the effect being significantly greater than that of the control subjects The differences in performance between the two control groups were not significant An analysis was also made of the data from a small group of deprivation quitters A poorer performance was again in evidence but because of a small sample the results were not significant

Another measure that has been employed is visual acuity Pollard, Uhr and Jackson (1963a) using an 8 hour period of perceptual deprivation, reported no changes in visual acuity or in lateral phoria as determined by the Bausch and Lomb Orthorater In the only other study Doane Mahatoo Heron and Scott (1959) appraised visual acuity by means of a horizontal row of 14 vertical black lines with each line in the series possessing a small gap of progressively decreasing width The lines were presented at a distance of 10 feet and the subject was required to indicate where the gap was in each line The experimental subjects showed an *increase* in visual acuity in contrast to no change in controls who received the same test 3 days apart Although the results only bordered on statistical significance the investigators attached considerable weight to this finding in view of the presence of a significant increase in tactual acuity in the same subjects Further research on visual acuity using a variety of measures seems to be indicated particularly because Friel and Derogatis (1965) and Rosenbaum Dobie and Cohen (1959) also reported an increase in visual efficiency but using a measure of tachistoscopic recognition thresholds

Finally, two unrelated experiments will be described briefly In the first Culver Cohen Silverman and Shmavonian (1964) presented their subjects with drawings of right or left body parts and asked them to identify the sidedness of the body parts Records were taken of the subject s latency in responding and the number of errors made No significant effect was observed after a 2 hour period of perceptual deprivation probably because of the briefness of the duration In the other experiment Ormiston and Finkelstein (1961) reported that a 2-day period of social isolation produced no changes on tests of target identification and warning light monitoring but did produce a significant decrement on an Aerial Reconnaissance Test in which the subjects were required to select particular objects on aerial photographs from a checklist of 17 possible objects

Auditory Measures

Although an extensive body of knowledge exists on the effects of sensory and perceptual deprivation on a wide variety of visual performance measures only limited attention has been paid to an appraisal of auditory functioning

Auditory vigilance and reaction time Undoubtedly the most careful work on this topic has been performed at the HumRRO laboratory at

Monterey, California (Myers, Murphy, Smith, & Windle, 1962 Myers, Smith & Murphy, 1963, Myers, Murphy, Smith, & Goffard, 1966) Vigilance was measured by the subject s speed of reaction to a brief tone signal, presented at a rate of 12 signals per 48 minute period, and occurring at irregular intervals The test was presented before and after 3 days of sensory deprivation Furthermore because it is known that irrelevant stimulation can facilitate vigilance, two control groups were employed, one tested in a lighted room and the other in a darkened test room

The results, summarized in Figure 7–4 indicate the presence of the classic performance decrement on the vigilance task with all three groups performing poorer on the second half of the task than on the first Of greater interest, however, are the comparative results The performance of the lighted room controls was significantly better than that of the darkness control group Furthermore, the experimental subjects outperformed both control groups but only the experimental darkness control difference was significant Thus, the vigilance performance of the isolated subjects did not differ from the controls tested in the light, but it was significantly *better* than that of the controls tested in darkness Observations were also made on a measure of simple auditory reaction time The results again revealed no differences between the experimentals and the lighted room controls but a significantly faster reaction time in the experimentals rela

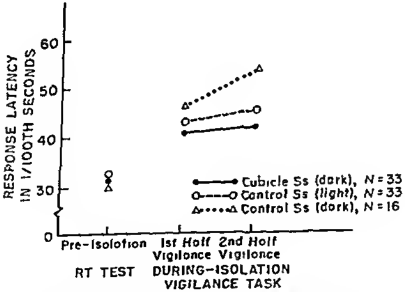

FIGURE 7–4 Average response latency on the first and second halves of an auditory vigilance task for cubicle subjects tested after 3 days of sensory deprivation, and for two control groups, one tested in darkness and the other in the light

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tive to the darkness controls The presence of these two auditory facilitatory effects is puzzling particularly since it has already been shown earlier that conditions of reduced sensory input produce a slower visual reaction time and poorer visual vigilance Whatever the explanation of these results may be, it is clear that the level of ambient illumination present in the test room is another important variable that must be contended with in future research

Partial support for these HumRRO results has been provided from the Manitoba laboratory (Zubek, Pushkar, Sansom, & Gowing, 1961) A group of 16 subjects tested before and after a week of sensory deprivation showed no significant change in auditory vigilance in relation to a control group receiving the same test in a lighted room Unfortunately, no control group tested under a condition of darkness was employed In a subsequent experiment from the same laboratory, a significant impairment of auditory vigilance was observed but the condition consisted of perceptual rather than sensory deprivation (Zubek et al, 1962) This differential effect is not too surprising since there is some evidence which suggests that greater behavioral and physiological deficits seem to occur after the perceptual deprivation condition (Zubek, 1964c)

Absolute and difference thresholds Suzuki, Fujii, and Onizawa (1965) using an audiometer, determined the absolute and difference limen in a group of subjects before and 1 hour after the termination of 18 hours of perceptual deprivation No significant changes were reported These negative results may be due to the delay in test administration, particularly since other studies from the same laboratory have demonstrated that certain perceptual changes disappear within an hour (Suzuki, Fujii & Onizawa, 1965, Ueno & Tada, 1965b)

Further evidence, of a striking nature, for the importance of the time of test administration is provided in a recent study of Glazer and Zenhausern (1966) Auditory thresholds were taken by a Beltone audiometer before and immediately after 5 minutes of sensory deprivation and subsequently every minute for 4 minutes The method of ascending limits was used with the check that the subjects had to correctly identify if 1, 2, or 3 pure tones (1 000 cps) were present The results revealed an oscillatory type of pattern i e an initial lowering of auditory threshold (increased acuity) an overswing to a raised threshold and then a return to the normal predeprivation level at the end of 4 minutes A further condition was also employed in which the sensory deprived subjects were stimulated with radiant heat An oscillatory pattern was again observed but in this case the auditory threshold was initially raised (poorer acuity), followed by an overswing to a lowered threshold and then a return to normal Although no satisfactory explanation can be given for this differential effect of the two conditions, this experiment is significant in two main respects First the presence of oscillatory changes points to a temporary

disturbance of some homeostatic regulatory mechanism such as the reticular activating system Second differential effects can occur whose nature is critically dependent upon the time of test administration

Finally in the only other short term study Batten (1961) reported no changes in difference thresholds for pitch after 1 hour of perceptual deprivation Although no information is provided as to the precise time of test administration it is possible that a delay of several minutes did occur particularly because both auditory and visual measures were taken on the same subjects If this did occur negative results might be expected

Other auditory measures One of the measures employed at the Princeton laboratory (Vernon McGill Gulick & Candland 1961) was a test of delayed auditory feedback in which the subjects were required to read aloud 100 two-syllable words while listening to a delayed feedback of their own voice Because the subjects were not permitted to talk or converse in any way during the 3 days of sensory deprivation it was predicted that the delayed feedback would exert a greater than usual disruptive effect upon their speech This was not the case All subjects but one isolated as well as controls improved in their ability to overcome the blocking effect from the pre- to the postexperimental period and to approximately the same degree

Leiderman (1962) employing the Seashore test of rhythm reported no significant changes on this measure after 2 to 6 hours of perceptual deprivation a finding which he believes may be related to a delay of 20 minutes in test administration

In summary it would appear that no changes an impairment or a significant improvement on certain auditory measures can occur after conditions of reduced sensory stimulation with the specific effects being determined by such variables as time of test administration ambient level of illumination in the test room and type of deprivation condition employed

Other Sensory and Perceptual Measures

Tactile perception A considerable body of evidence indicates that not only auditory performance but also tactual acuity can be facilitated by isolation The earliest demonstration of an increase in tactual acuity was made at the McGill laboratory (Doane Mahatoo Heron & Scott 1959) in which two-point threshold determinations were taken from five subjects before and then at intervals of 2 and 3 days of perceptual deprivation A group of 20 controls was used for comparative purposes The results summarized in Table 7–2 indicate an increase in tactual acuity of the forehead and upper arm after both time intervals effects which were significantly greater than that of the controls Furthermore this facilitatory effect seems to be greater after 2 days than 3 days No significant changes were seen on the finger and forearm although a strong suggestion of

TABLE 7 2 Mean Values for Two Point Limen for 5 Experimental Subjects (4 in the 72 Hour Test) and 20 Normal Control Subjects

		Test Periods			*p values*[1] *(U test)*	
Locus	Group	Pre isolation	48 hrs	72 hrs	1 2	1 3
Finger	Experimental	1 70	1 70	1 75	NS	
	Control	1 75	1 50	1 60		
Forearm	Experimental	29 6	26 7	24 0		
	Control	23 4	23 3	23 7	15	15
Upper Arm	Experimental	29 1	21 9	23 8		
	Control	32 8	32 8	32 4	002	05
Forehead	Experimental	19 8	16 9	19 2		
	Control	9 2	9 2	9 2	02	02

[1] p-values are based on each subject's change in score as between the first and second and first and third test.

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increased acuity of the forearm was in evidence Although these two negative results might be attributed to the smallness of the experimental sample another possibility at least for the finger, is that the two-point limen technique is not sufficiently accurate to demonstrate increased sensitivity in an area of the skin which normally is highly sensitive

Using a more sensitive measure of tactual acuity (tactual fusion) Zubek (1964b) reported a significant increase in acuity of both the index finger and forearm after a week of perceptual deprivation All 12 experimental subjects showed increased forearm acuity and 11 of the 12 an increased finger acuity on the second threshold determination On the other hand the controls exhibited a chance distribution of increases and decreases Further analysis revealed that the increased acuity was not related to the presence or absence of gloves It occurred in both cases and to approximately the same degree Similar results have also been demonstrated at the Japanese laboratory after 2 days of perceptual deprivation Nagatsuka and Maruyama (1963) reported a significant increase in the tactual acuity of the back of the hand (two-point limen) It is interesting to note that eight of the nine experimental subjects showed the effect Experimental verification of this phenomenon was provided in a subsequent experiment (Nagatsuka & Suzuki 1964)

Further research appears to suggest that this increase in tactual acuity does not occur after short term deprivation Pollard Uhr and Jackson (1963a) observed no changes in the two-point limen after 8 hours of

perceptual deprivation. Similar results appeared when the same subjects were exposed to a second deprivation period a week later. No significant changes also occur on measures of two-point limen, identification of letters traced on the skin, and tactile localization administered before and after 2 hours of sensory deprivation (Cohen, Silverman, & Shmavonian, 1962a; Culver, Cohen, Silverman, & Shmavonian, 1964). Finally, Reitman and Cleveland (1964) reported no significant changes in two-point limen or on light touch sensitivity (Von Frey hairs) in a group of nonpsychotic patients exposed to 4 hours of perceptual deprivation. Surprisingly, however, a group of isolated schizophrenics showed a significant increase in sensitivity on both measures in relation to a group of schizophrenic controls. In view of these intriguing results, further research is required not only on schizophrenic but also on other types of psychotic patients. Additional research is also indicated on the tactual acuity of normal subjects to determine the minimum duration required to produce this now well established facilitatory effect.

Although tactual acuity is unquestionably better after prolonged deprivation, performance on tactual form discrimination appears to be worse. Doane, Mahatoo, Heron, and Scott (1959) presented blindfolded subjects with a set of ten different wire figures and asked them to identify the figures by tracing the outline of each figure with their finger. The task was presented before and then at intervals of 2 and 3 days of perceptual deprivation. Table 7.3 indicates that the control subjects showed a practice effect on the second and third test periods, whereas the performance of the experimentals deteriorated significantly at both test periods. Furthermore, it is important to note that the deficit was much greater after the second than after the third day of deprivation. This finding, together with a similar temporal effect on tactual acuity, provides further evidence for the fact that 2-day durations often result in greater behavioral changes than either shorter or longer experimental periods.

TABLE 7.3 Mean Error Scores on Tactual Form Discrimination of Three Test Periods for 8 Experimental Subjects (7 in the 72 Hour Test) and 20 Normal Control Subjects

Group	Test Periods: Preisolation	48 hrs	72 hrs	p-values[1] (t test): 1-2	1-3
Experimental	2.06	3.30	2.70	.001	.02
Control	2.63	2.08	2.03		

[1] p-values are based on each subject's change in score as between first and second, and first and third test.

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In attempting to account for the divergent results on tactual acuity and tactual form discrimination Doane, Mahatoo, Heron, and Scott (1959) suggest that the deficit on the latter measure may represent a visual dysfunction Many of the subjects remarked that they had lost their ability to visualize the appearance of the various figures which initially were presented to them without a blindfold

Pain perception An increased sensitivity to pain can also occur but apparently only under conditions of sensory deprivation Vernon and McGill (1961) measuring the absolute threshold of electrical pain of the earlobe, reported a 42 percent increase in pain sensitivity after 4 days of sensory deprivation in contrast to an increase of only 5 percent in a group of controls Of the nine experimental subjects, all but one showed this change In discussing these results in a subsequent publication, Vernon (1963) raised two intriguing questions First, since a 42 percent increase was obtained after 4 days, would one day yield a 10 percent change? Second, would longer periods lead to an even greater increase in sensitivity? Although a linear increase in pain sensitivity may occur with increasing durations a more likely possibility is that the greatest increases will occur early in the deprivation period and subsequently diminish with time Some support for this hypothesis has been provided by Doane and coworkers who observed a greater increase in tactual acuity after 2 days than after 3

Contrary results were reported by Zubek et al (1962) who, using a 1 week period of perceptual deprivation and a radiant heat technique for eliciting pricking pain, reported a significant *decrease* in sensitivity Although this discrepancy might be attributed to the use of a 7-day rather than a 4-day period this appears unlikely since in two subsequent studies at the Manitoba laboratory, using 7 days of visual deprivation alone, a significant increase in pain sensitivity was observed (Zubek, Flye, & Aftanas, 1964, Zubek, Flye & Willows, 1964) A more likely possibility is that this decrease, occurring after perceptual deprivation, resulted from the constant exposure to white noise Both Gardner and Licklider (1959) and Carlin Ward, Gershorn and Ingraham (1962) have reported that white noise has certain analgesic properties Furthermore, Licklider (1961) has stated that "Mountcastle has found cells both in the posterior group nuclei and in the cerebral cortex, which respond to nociceptive stimulation and whose responses are suppressed by acoustic stimulation (p 70) It would appear, therefore, that the presence or absence of white noise may be the critical factor Furthermore these findings suggest that qualitatively different results may be produced by sensory and perceptual deprivation a finding also applicable to measures of vigilance Sensory deprivation seems to facilitate auditory vigilance whereas perceptual deprivation tends to impair it

An increase in pain sensitivity can occur even after very brief durations Glazer and Zenhausern (1966) measuring the absolute threshold of

pricking pain reported an increase in pain sensitivity immediately after 5 minutes of sensory deprivation Subsequent testing at intervals of a minute for 4 minutes revealed an overswing to decreased sensitivity and then a return to normal sensitivity an oscillatory type of phenomenon which they also reported for the absolute threshold of hearing Identical results were also obtained in a second group of experimental subjects who were visually deprived but exposed to a 1 000 cycle pure tone An interesting speculation is whether an increase in pain sensitivity would have occurred if white noise rather than a pure tone had been employed during the 5 minute deprivation period

Gustatory perception Because significant increases on certain visual auditory and cutaneous measures of performance have been reported one might expect a similar increase in taste sensitivity This appears to be the case The Japanese investigator Nagatsuka (1965) reported a 36 percent increase in sensitivity to sweet and bitter after 1 day of perceptual deprivation in contrast to no change in a group of controls Measures of sensitivity to sour and salty substances unfortunately were not taken

Kinesthetic acuity and spatial orientation Measures of kinesthetic acuity appear to lie unaffected by prolonged periods of deprivation Zubek (1964b) reported no changes in kinesthetic acuity after a week of perceptual deprivation In this study the subjects were required to bend their elbow to what they felt was either a 20° or a 60° angle Hanna and Gaito (1960) also observed no changes on a test measuring the ability to discriminate seven small cubes differing slightly in weight A 6-day period of confinement was employed

On the other hand kinesthetic measures involving spatial orientation appear to be severely disrupted Doane Mahatoo Heron and Scott (1959) tested spatial orientation in two ways both requiring that the subject follow directions in making a series of movements while blindfolded The first was a paper and pencil test in which the subject had to draw a route consisting of five right angle turns In the second measure the same principle was involved but here the subject was placed in an empty room and required to follow directions by walking The two tests which were scored in terms of distances and angles from the correct ones were administered before and then at intervals of 2 and 3 days of perceptual deprivation In the estimation of distance the experimentals did not differ from the controls but in the judgment of angles and directions they were significantly inferior on both measures Furthermore on the walking test the performance was poorer after 3 days of isolation than after 2 days However on the paper and pencil test of spatial orientation the performance was much poorer after 2 days than after 3 a temporal effect seen on several other types of sensory and perceptual motor measures

This impairment of spatial orientation is attributed by Doane and co-workers to a visual dysfunction resulting from an inability to visualize the external world This made it impossible for them to form a mental

picture of the route that had to be followed in the orientation test and thus to locate the starting point (p 218)

Measures of Motor Coordination

Simple measures There seems little doubt that dexterity and other measures of simple eye hand coordination are impaired At the Manitoba laboratory an appraisal was made of such abilities as speed of cancellation of a particular number on a page of randomized numbers placing a dot in small triangles making two check marks in squares and tracing a line through a maze without touching the sides All measures showed a significant impairment during a week of either sensory or perceptual deprivation (Zubek Sansom & Prysiazniuk 1960 Zubek et al 1962) These deficits were also observed in the isolation quitters No significant differences however occurred between 1 week recumbent and ambulatory control subjects Essentially similar results were reported from the HumRRO laboratory (Myers Murphy Smith & Goffard 1966) The MacQuarrie Test of Mechanical Skills consisting of seven subtests—i e Tracing Tapping Dotting Copying Location Blocks and Pursuit—was administered to 32 subjects after 3 days of sensory deprivation The experimentals performed significantly worse than a group of 47 controls on all tests except Tapping and Blocks Evidence of motor incoordination was also obtained at the McGill laboratory (Bexton Heron & Scott 1954 Scott Bexton Heron & Doane 1959) The experimental subjects were not only slower in copying a prose paragraph but the quality of their handwriting was poorer

Two somewhat different measures were employed by Vernon (1963) and Vernon McGill Gulick and Candland (1959 1961) One of these was a test of rail walking ability in which the subjects simply had to walk along an 18 foot wooden rail in stocking feet Performance was measured by the time in seconds required to complete the task administered before and after a 3-day period of sensory deprivation The results revealed that whereas the controls showed an improvement of 8 percent the experimentals not only did not improve but on the average were 42 percent worse In the second test hand tremor was measured by requiring the subject to hold a small metal stylus within a hole in a metal plate the plate and stylus being wired so that each contact between them activated a timer The results were quite unexpected No changes were observed However upon reanalyzing the data according to whether the subjects succeeded or failed it was observed that the subjects who endured the prescribed duration showed a significant increase in hand tremor while the isolation quitters showed a statistically significant decrease Obviously when considered as a single group these two opposite trends had cancelled each other a phenomenon which Vernon also reported for visual reaction time

Because these results are the reverse of what one would expect Vernon (1963) attributes the greater steadiness of the quitters to be a possible calming effect resulting from a release from a situation which each had found intolerable

Measures of simple motor coordination can be impaired not only by sensory and perceptual deprivation but also by *social isolation alone* provided that unusually long durations are employed Walters Callagan and Newman (1963) reported no significant changes on a manual dexterity test (tweezers) in a group of prison inmates socially isolated in cells for 4 days However the Soviet investigators Agadzhanian Bizin Doronin and Kuznetsov (1963) observed a progressive increase in the time required to trace a geometric figure in subjects socially isolated for 60 days The drawing time at the end of the experiment was approximately twice what it was during the first month No changes occurred in the quality of the tracing

Complex measures Performance on a mirror tracing task can also be impaired but only by an experimental period of medium duration Vernon McGill Gulick and Candland (1961) required subjects to trace a six pointed star, while looking at a mirror before and after 1 2 or 3 days of sensory deprivation Performance measures were the amount of time required to complete the task and the number of errors committed The results on the time measure are shown in Figure 7–5 It can be seen that there is no change in performance in the control subjects from the first to the third day and no difference between the controls and experimentals after either the first or third day However the mirror tracing performance of the 2 day deprived group is much poorer than that of the control group An analysis of the error scores indicated why this differential effect occurred Fewer errors were made by the 2 day isolated group than were made by either the 1 or 3-day groups These data seem to suggest that the 2 day experimentals slowed their time performance in order to improve the quality of the tracing The finding that a 3-day duration has no effect is supported by Scott Bexton Heron and Doane (1959) who using a time measure of mirror tracing and a 3-day period of perceptual deprivation also observed no significant changes in performance

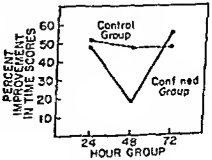

FIGURE 7–5 Mirror tracing data (time scores) percent improvement from the pre- to the postexperimental period

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The only other measure of complex motor coordination which has been employed is rotary pursuit performance Results similar to those for mirror tracing were reported by Vernon McGill Gulick & Candland (1959 1961) i e a significant impairment after a 2-day period but no significant changes after either a 1 or 3-day period of sensory deprivation Since a 1-day period appears to have no effect on a rotary pursuit task one would expect that similar results would appear after even shorter periods of deprivation This apparently is not the case Freedman and Greenblatt (1959) reported a significant impairment on a pursuit rotor task after 8 hours of sensory deprivation and a poorer but not statistically significant performance after a similar period of perceptual deprivation Ormiston (1961) employing a somewhat different measure (dual compensatory tracking task) also observed no significant changes after 8 hours of perceptual deprivation Further research employing durations of 8 to 24 hours is required to clarify these seemingly contradictory results on rotary pursuit

In summary it would appear that both simple and complex measures of visual motor coordination are adversely affected by conditions of reduced sensory stimulation Furthermore since the variable of simple eye hand coordination enters into many of the tests of intellectual performance that have been used in the past it is possible that at least some of the intellectual decrements observed during isolation might be attributable to a perceptual motor dysfunction (see chapter 5)

SINGLE MODALITY DEPRIVATION

Visual Deprivation

Long duration studies In the preceding section it was shown that significant increases in tactual acuity pain sensitivity gustatory sensitivity and an improvement on certain auditory measures can occur after prolonged periods of deprivation Recently four experiments from the Manitoba laboratory have indicated that similar facilitatory effects can result from visual deprivation alone An overall reduction in sensory input from several modalities is not essential

In the first study (Zubek Flye & Aftanas 1964) 16 subjects were placed in groups of two in a room for a week Apart from constant darkness the sensory environment was quite normal with no restrictions on movement conversation or use of a radio Measures of tactual acuity were taken from the index finger palm and forearm before and immediately after a week of darkness and subsequently at intervals of 1 2 5 and 7 days The acuity of the palm was measured by the two-point limen technique while that of the index finger and forearm was determined by a tactual fusion technique This technique employs an interrupted jet of air the frequency of which can be increased until the subject reports a

constant, uninterrupted sensation of pressure In addition to these measures of tactual acuity the *Hardy Wolff and Goodell dolorimeter (radiant heat)* was employed to determine the heat and pain sensitivity of the forearm A significant increase in tactual acuity occurred on all three skin areas with the aftereffects persisting for several days 1 day for the palm 2 days for the index finger, and even longer for the forearm An examination of the individual data revealed that increased tactual acuity was shown by all 16 experimental subjects and on all skin areas

The results on heat and pain sensitivity are shown in Figure 7–6 Again there was a significant increase in sensitivity which persisted for 2 days for pain and 1 day for heat Note the gradual return to normal sensitivity during the 7 day postexperimental period The effect was again shown by all experimental subjects on both measures

The purpose of the second experiment (Zubek Flye, & Willows 1964) was to determine whether effects similar to those of darkness, could be produced by a 7 day exposure to diffuse homogeneous illumination The procedure was identical to that of the previous experiment with the exception of a pair of translucent goggles which were worn at all times The results revealed a significant increase in heat and pain sensitivity with the aftereffects persisting for 2 days for heat and 1 day for pain

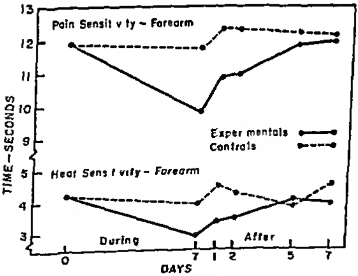

FIGURE 7–6 Heat and pain sensitivity of the forearm before and after a week of visual deprivation (darkness) and 1 2 5 and 7 days later

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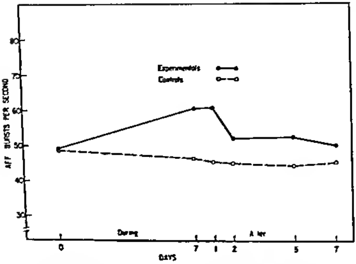

FIGURE 7–7 Changes in auditory flutter fusion (AFF) before and after a week of visual deprivation (darkness) and 1, 2 5, and 7 days later

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Similar results were reported for tactual acuity with the aftereffects persisting for a day for the finger and no persistence on the forearm Finally, the palm revealed a slight though not statistically significant increase which the authors attributed to a lack of sufficient sensitivity of the 2 point limen technique Uniformity of the individual data was again seen but this was not as striking as under the darkness condition Thus significant increases in cutaneous sensitivity can occur after prolonged exposure to either darkness or homogeneous illumination Furthermore the somewhat smaller effects produced by the latter condition are attributed by the authors to the presence of random fluctuations in illumination resulting from the opening and closing of the eyes together with movements of the head away from the overhead light source—a factor not present during the darkness condition These random fluctuations in level of illumination probably served to alert the neurovisual system periodically and hence diminished the magnitude of the effects

During the course of these two experiments several of the subjects reported spontaneously that their sense of hearing seemed to be much better In view of these remarks two types of auditory determinations were made in the third study (Duda & Zubek 1965) These were administered to a group of 15 subjects before and immediately after a week of darkness and subsequently at intervals of 1 2 5 and 7 days The first test involved the measurement of auditory discrimination using an auditory flutter technique (interrupted white noise at a 0 90 on-off ratio) and the second consisted in the determination of the absolute threshold of hear

ing for five different frequencies viz, 100 300 1 000 5 000 and 9 000 cps

The results shown in Figure 7–7, revealed a significant improvement on the auditory flutter fusion task with the aftereffects persisting for 1 day All experimental subjects but one showed this increased sensitivity On the other hand the absolute threshold of hearing for the five frequencies was not affected Furthermore no trends were evident The failure of this second auditory measure to show a significant improvement is puzzling It may however simply indicate that this facilitatory effect is only evident on auditory measures involving a temporal discrimination Whatever the explanation may be it is clear that the answer is dependent upon further research using a variety of other measures not only of auditory but also of cutaneous functioning Such a program is currently under way at the Manitoba laboratory

The final study (Schutte & Zubek 1967) was concerned with the measurement of olfactory and gustatory sensitivity Figure 7–8 shows an increase in olfactory sensitivity (recognition threshold for benzene) in the experimental relative to the control subjects after a week of darkness

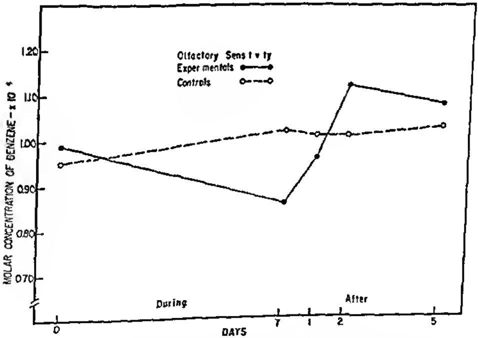
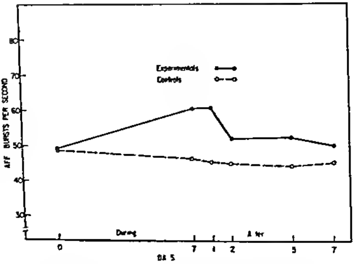


FIGURE 7–8 Changes in olfactory sensitivity (recognition threshold for benzene) before and after a week of visual deprivation (darkness) and 1, 2, and 5 days later Note the suggestion of an overswing to decreased olfactory sensitivity in the experimental subjects on post deprivation day 2

SOURCE Reprinted by permission of University of Toronto Press from W Schutte & J P Zubek Canad J Psychol, 1967 21 358–36?



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(1962b) studied the tactual acuity of the index finger thumb and forearm of a group of eight women working for 8 hours in the light and a group of seven women working for a similar duration in total darkness According to this investigator the subjects working in darkness possessed much poorer tactual acuity on all three skin areas than did those working in the light This finding however is questionable since a difference in acuity of approximately the same magnitude existed between the two groups both before and after the 8 hour period In view of this a statistical treatment involving a difference of differences analysis would undoubtedly have yielded negative results It would appear therefore that 8 hours of visual deprivation is not sufficiently long to produce significant changes in tactual acuity Further support for this hypothesis is provided by Pollard Uhr and Jackson (1963a) who observed no changes in the two point threshold after 8 hours of combined visual and auditory deprivation

Several scattered observations have been made on the nature of auditory functioning after short term visual deprivation Cohen (1962) compared the performance of a group of subjects who were exposed to 20 minutes of darkness of a Ganzfeld (a uniform textureless field) and of a control condition on three auditory measures viz the Seashore loudness-discrimination test discrimination between odd and even numbers and discrimination between one or two tones Although no significant differences were found on the third task more errors were produced on the Seashore test by both the Ganzfeld and darkness conditions relative to the control condition A similar impairment was observed on the odd-even numbers test but with the Ganzfeld producing a significantly greater degree of impairment than the darkness condition

Further support for the existence of an auditory impairment after short term deprivation is provided by Özbaydar (1961) who determined the absolute threshold difference threshold and masked threshold for a 1 200 cps tone in subjects tested after 10 minutes of either darkness or light Although no change was found on the difference threshold the darkness condition produced a small but reliable impairment of both absolute and masked thresholds

In another experiment on auditory functioning Leiderman (1962) reported no significant changes on the Seashore test of rhythm after 2 to 6 hours of visual deprivation (translucent Ping Pong balls) Bakan and Manley (1963) on the other hand reported a significant improvement on an auditory vigilance task in a group of male subjects tested immediately after 15 minutes of darkness a finding also observed at the HumRRO laboratory in a study on prolonged sensory deprivation Female subjects surprisingly showed no change Thus increases decreases or no changes in auditory functioning can occur after short term visual deprivation with the specific results being largely dependent upon the particular measures used

($p < .02$) No significant differences between the two groups were present on postdeprivation days 1, 2, and 5, indicating that this facilitatory effect is only present immediately after the termination of visual deprivation It is interesting to note, however, a suggestion of an oscillatory phenomenon, i e, an 'overswing to decreased olfactory sensitivity 2 days after the termination of the experimental condition, a picture similar in nature to that reported by Glazer and Zenhausern (1966) for pain and auditory sensitivity

The measures of taste thresholds yielded a differential pattern of results Sensitivity to NaCl (salty) and sucrose (sweet) was increased significantly after visual deprivation with the aftereffects persisting for 1 day after restoration of normal visual stimulation No suggestion of an oscillatory pattern was evident Sensitivity to HCl (sour) and quinine (bitter) on the other hand, was not changed significantly although a marked trend for sour was evident immediately after visual deprivation Eleven of the 12 experimental subjects showed an increased sensitivity to sour, a proportion identical to that observed with salt and sucrose These differential results although perplexing in nature, appear to be related to the percent concentration of the four taste substances that were employed Quinine and HCl, which subjects can normally detect at very low concentrations, produced negative results whereas NaCl and sucrose to which subjects are much less sensitive, resulted in a significant improvement If concentration is the critical variable, it is possible that increased sensitivity to both bitter and sour would have occurred if other taste substances, to which subjects are less sensitive, had been substituted for quinine and HCl

The failure to demonstrate even a trend toward greater sensitivity to bitter is puzzling since Nagatsuka (1965) reported that a 1-day period of perceptual deprivation produced a 36 percent improvement in sensitivity to quinine One possible explanation of this difference may be that this primary taste quality is only affected by combined visual auditory deprivation and not by visual deprivation alone A more likely possibility, however, is that this specific facilitatory effect only occurs after relatively short periods of deprivation and not after a week when most of the changes may have dissipated Considerable evidence has already been presented for a recovery of function with increasing durations, with periods of 1 or 2 days frequently producing greater behavioral effects than longer durations Regardless of the reason for this discrepancy in results it is clear that future research in this area should be directed at the temporal course of sensory changes occurring at various intervals of a prolonged duration If this were to be done some of the apparently contradictory results derived from short term and long term deprivation studies might be resolved

Short duration studies Only one short term study has been concerned with changes in tactual acuity after visual deprivation alone Using a two-point threshold technique the Soviet investigator Kamchatnov

retical model can cope satisfactorily with the long term deprivation effects it appears unable to account for the variety of short term deprivation effects It is possible though that these latter phenomena have resulted largely from certain psychological variables rather than from a disturbance of a neural regulatory system

Auditory Deprivation

Schultz s (1965) sensoristatic model would predict that not only visual deprivation but also auditory deprivation alone should produce an increased sensitivity in other modalities Unfortunately no relevant data on this topic is as yet available although a program of research on the effects of auditory deprivation will shortly be underway at the Manitoba laboratory

Long duration studies Three studies have been conducted whose object was to determine changes in auditory functioning as a result of prolonged exposure to either constant noise or an absence of noise In the first study the Soviet investigator Krylov (1965) placed a group of eight subjects in a small hermetic chamber for periods ranging from 27 to 30 days During this interval they were exposed to constant noise ranging in intensity from 55 to 65 db for the different subjects Auditory thresholds for tones of 125 250 500 1 000 3 000 and 8 000 cps were taken at periodic intervals by means of an audiometer and a telephone located in the chamber The results revealed an initial increase in auditory sensitivity most prominent at the end of the first day (5 to 7 5 db) a subsequent period of relatively little change up to the 23rd or 24th day and a further increase in sensitivity during the last several days of the experimental period Unfortunately these findings are difficult to evaluate because a control group tested at the same time intervals as the experimental subjects was not employed Krylov suggests that the progressive improvement in hearing following prolonged exposure to noise reflects an intensified excitatory process in the cerebral cortex

The second study reported by Rosen et al (1962) involved the determination of auditory thresholds of tones ranging from 500 to 6 000 cps in a group of Mabaans living in a relatively noise free environment in a remote region of the Sudan The results revealed a striking superiority in hearing of the Mabaans compared to urban populations in the U S A In a subsequent study (Rosen Plester El Mofty & Rosen 1964) the testing range was increased to cover frequencies from 12 000 to 24 000 cps At least 100 subjects in each decade from ages 10 to over 70 were employed For comparative purposes similar tests were administered in New York Dusseldorf and Cairo The results for a frequency of 14 000 cps are shown in Figure 7–9 It can be seen that the auditory acuity of the Mabaans is clearly superior to that of the three city groups Furthermore the

Finally, several studies will be reviewed whose purpose was to appraise the effect of visual deprivation on a wide variety of visual measures. Leiderman (1962), in addition to using the Seashore test of rhythm, also took measures of c.f.f., reversible figures, simple and choice reaction time, and the Gottschaldt Embedded Figures. No significant changes occurred after 2 to 6 hours of visual deprivation, a finding which may be related to a delay of 20 minutes in test administration. Although Leiderman observed no change in simple visual reaction time, Kamchatnov (1962a) reported a significant slowing on a test given immediately after 8 hours of darkness.

Finally, a considerable body of experimental data exists on the effects of brief periods of exposure to a completely homogeneous visual field—the Ganzfeld. Because this extensive literature has recently been reviewed by Avant (1965), it is sufficient for our purposes to present his conclusions; viz., "The data show the experience of such fields to be characterized by reports of: immersion in a 'sea of light' which separates into figure and ground as brightness is increased, chromatic adaptation in colored fields, loss of efficiency in detecting the presence of movement of inhomogeneities introduced into the field, disorientation of the observer, an increased and fluctuating state of accommodation, and the occasional joint occurrence of an apparent cessation of the function of the visual mechanism and increased alpha activity in the brain" (p. 246).

In summary, it would appear that prolonged periods of visual deprivation alone can produce significant increases in cutaneous, auditory, gustatory, and olfactory sensitivity, effects which with one exception have also been demonstrated after prolonged sensory and perceptual deprivation. These findings are significant in two respects. First, they suggest that some of the other effects produced by sensory and perceptual deprivation may also occur after visual deprivation alone. Second, these results are of considerable theoretical importance since they seem to support the sensoristatic model of the nervous system recently formulated by Schultz (1965). According to Schultz, sensoristasis is a condition in which the organism strives to maintain an optimal range of sensory variation, a range which is capable of shifting to some degree as a function of several variables. The monitor serving to maintain the sensoristatic balance is the reticular activating system which Lindsley (1961) conceives of as serving as a sort of "homeostat" or regulator adjusting "input-output" relations. One of the predictions which Schultz derives from his model is that "when stimulus variation is restricted, central regulation of threshold sensitivities will function to lower sensory thresholds. Thus, the organism becomes increasingly sensitized to stimulation in an attempt to restore the balance" (p. 32). The demonstration of an increase in cutaneous, auditory, gustatory, and olfactory sensitivity following prolonged visual deprivation appears to support this theoretical prediction. Although this theo-

Tactual Deprivation

Experiments on skin occlusion In the preceding section it was shown that prolonged exposure to auditory deprivation produces an increase in auditory sensitivity An increase in tactile sensitivity can also occur after prolonged tactual deprivation Braunstein (1957) and Heron (1961) both working at the McGill laboratory bandaged a perforated plastic cup 3 by 6 centimeters onto the volar surface of the forearm for a period of 4 days The sensitivity of the occluded area was then tested by means of von Frey hairs before and immediately after the experimental period An area on the contralateral arm served as a control condition In both exploratory studies an increase in sensitivity was observed but it was not statistically significant relative to that of the control arm However in both of these studies the control area used was on the contralateral limb and was *homologous* with the isolated area If the effect is central changes might occur in both the experimental and control area thus masking the true effect

As a check on this possibility Heron and Morrison performed two experiments as yet unpublished In the first the same procedure was used but the control area on the contralateral arm was in a more distal position so that it was not homologous with that on the experimental arm All subjects showed a greater increase in tactile sensitivity on the isolated than on the control area ($p < 01$) In the second experiment the same procedure was again used but the measures were taken not only on the occluded arm but also on two areas on the contralateral limb one homologous and the other nonhomologous The data revealed a considerable increase in the sensitivity of the occluded area while that of the non homologous control area remained virtually unchanged The homologous skin surface on the contralateral arm also showed a greater sensitivity but the change only bordered on statistical significance

These results have not only been verified at the Manitoba laboratory but have also been extended in several new directions Aftanas and Zubek (1963a 1963b) studied changes in tactual acuity (tactual fusion method) and in heat and pain sensitivity under three conditions (1) no tactile stimulation (2) constant pressure and (3) a control condition In all three conditions the test area was located on the volar surface of the forearm 8 cm below the elbow The no stimulation condition was similar to that employed at the McGill laboratory involving the attachment of a perforated cup to the skin The constant pressure condition was produced by the use of a perforated disc covered by a plastic cup In the control condition an open plastic ring was bandaged to the forearm Each condition lasted a week with the measurements being taken before and immediately after each condition and then daily for 6 days thereafter

The results for tactual acuity are shown in Figure 7–10 It can be seen that the no-stimulation condition produces a considerable increase in

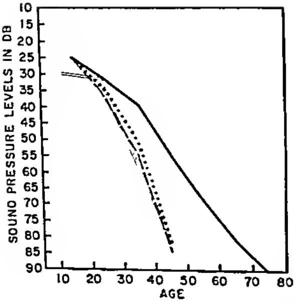

FIGURE 7–9. Comparison of decade audiograms at 14,000 c.p.s. (medians) of Mabaans (solid line), New York (dotted line), Düsseldorf (broken line), and Cairo (double line).

SOURCE: Reprinted by permission from S. Rosen et al., *Arch. Otol.*, 1964, 79, 18–32.

disparity in favor of the Mabaans becomes progressively greater with increasing age of the subjects. A similar picture was evident for frequencies both above and below 14,000 cps.

In discussing this data, the investigators suggest that the phenomenon of presbycusis, or progressive loss of hearing of high frequencies with age, is largely an environmental phenomenon; i.e., it appears to be related to the noise level in the environment. Further support for this hypothesis is provided by the fact that in the Mabaans, all of whom live in a noise-free environment, there are no sex differences in hearing losses whereas in our culture males, who generally are professionally exposed to more noise than women, show greater hearing losses with age. These results on the Mabaans also have an important implication for research in developmental psychology. They indicate that the developmental and aging curves for various sensory and perceptual processes may be quite different for various cultural groups particularly those living in impoverished or unusual sensory environments.

These results reported by Krylov and Rosen et al. are puzzling because in one case they suggest that prolonged exposure to noise improves auditory sensitivity whereas in the other it appears to have a detrimental effect. Perhaps a replication of the Krylov experiment, with appropriate controls, may resolve these apparently contradictory findings.

Short-duration studies. Various measures of auditory and visual performance seem to be unaffected by short term auditory deprivation. Batten (1961) observed no changes in pitch or brightness discrimination after a 1-hour exposure to constant white noise. Leiderman (1962), also using white noise but of 2 to 6 hours' duration, reported no significant changes in the Seashore test of rhythm, the c.f.f., reversible figures, Gottschaldt figures, and simple and choice reaction time.

day whereas in the earlier research they persisted for much longer This discrepancy may be attributable to the fact that the *preexperimental* tactual acuity of the three groups of subjects was somewhat greater than that of the subjects previously employed (see Figures 7–10 and 7–11) A *relationship between level of initial tactual acuity and duration of after effects may be indicated*

The highly specific locus of these changes in tactual acuity would appear to rule out the involvement of the reticular activating system A more likely possibility is that tactual deprivation produces changes in the central areas of the primary somesthetic system, similar in nature to the supersensitivity occurring in the sensory cortex following partial deafferentation at lower levels of the central nervous system (Stavraky, 1961) Of these supersensitivity phenomena the one most directly relevant was reported by Spiegel and Szekely (1955) who observed that lesions in the posteroventral nucleus of the thalamus (relay nucleus for touch) are subsequently followed after an initial period of depression by a hyperexcitability of the somesthetic cortex *Thus isolation of a circumscribed area of the skin may produce a state of temporary partial deafferentation of the somesthetic system* However, this deafferentation is of a functional rather than a surgical nature

Amputee studies These results, derived from the skin-occlusion experiments, are also in agreement with a series of studies on unilateral am

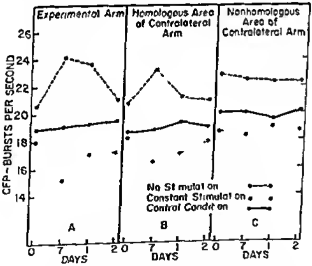

FIGURE 7–11 Tactual acuity of the control and two experimental groups, for three different skin areas before and after a week, and 1 and 2 days later

SOURCE Reprinted by permission from M Aftanas & J P Zubek *Percept mot Skills* 1964 18 437–442

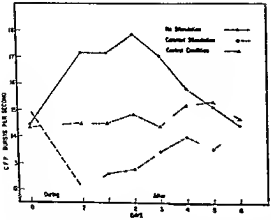

FIGURE 7–10 Tactual acuity of the forearm of the control and two experimental groups before and after a week and 1, 2 3, 4 5 and 6 days later

SOURCE Reprinted by permission from M Aftanas & J P Zubek *Percept mot Skills* 1963 17 867–870

tactual acuity while constant pressure produces a decrease in acuity No changes are produced by the control condition Even more striking are the unusually long aftereffects which persisted for 5 days for no stimula tion and up to 6 days or longer for constant pressure In contrast to these results no significant changes were observed on the heat and pain thresh old measures These negative findings are not too surprising since the experimental cups in actual practice probably did little to change the frequency of occurrence of heat and pain We are so infrequently sub jected to painful stimulation for example that application of a protective device to the skin really does not minimize its incidence

In interpreting these results on tactual acuity the authors postulate the operation of central rather than peripheral mechanisms arguing that such peripheral factors as impaired circulation and skin distortion are unlikely to account for the presence of aftereffects 5 or 6 days later In order to test this hypothesis another experiment was conducted whose purpose was to determine whether the changes in tactual acuity will trans fer to the contralateral limb (Aftanas & Zubek 1964a) If they can be demonstrated in the nonexperimental arm central mechanisms would clearly be involved Three conditions were again employed and two mea sures of tactual acuity two-point threshold and tactual fusion were taken before and immediately after a 1 week period and 1 and 2 days later The measures were taken from the occluded area on the left forearm and from a nonoccluded homologous and nonhomologous area (wrist) on the con tralateral limb Figure 7–11 shows the results on tactual acuity as deter mined by the fusion method Again it can be seen that the no-stimulation condition produces an increase in tactual acuity on the experimental arm and the constant pressure condition a decrease in acuity Furthermore similar changes although not as pronounced also appear on the ho- mologous area of the contralateral arm No changes occurred on the non homologous area indicating that the effects are quite specific. The two-point threshold technique revealed essentially similar results An unex pected finding was the presence of aftereffects which persisted for only a

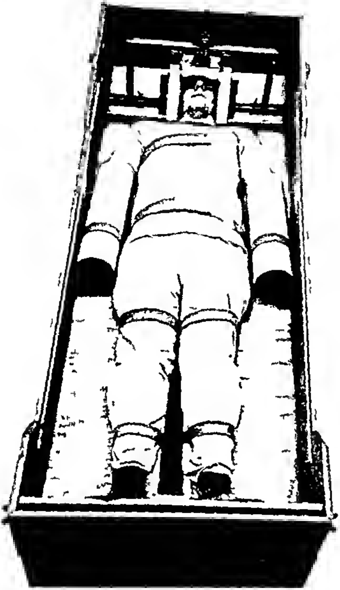

FIGURE 7–12 *A photograph of a subject in an immobilization box employed at the University of Manitoba to study the effects of kinesthetic or motor deprivation The overhead viewing frame, on which pictures are placed, has been removed for photographic purposes*

SOURCE Reprinted by permission of University of Toronto Press from J P Zubek & M MacNeill Canad J Psychol, 1966 20, 316–336

trols Pain sensitivity, tactual acuity, and a test of cancellation of numbers were not affected

Because some of these deficits might have resulted from physical discomfort and pain, which the subjects frequently reported, an exploratory study, of 1 week duration, was conducted (Zubek & Wilgosh, 1963) The condition, however, was made less stressful by unstrapping the subjects at mealtimes, once a day to go to the washroom, and for 9 hours during the night The results revealed a significant impairment of cancellation, color discrimination, and reversible figures with the deficit on dexterity bordering on statistical significance Measures of depth perception and size constancy, which were employed for the first time, were not affected, a finding also observed in studies on sensory and perceptual deprivation

The final study (Zubek & MacNeill 1966) was essentially a replication of the exploratory study but with a much larger sample and an inclusion of a 1 week recumbent control group in addition to ambulatory control subjects The pattern of results was identical to that of the previous experiment Further analysis of the data revealed that the significantly slower rate of figure reversals resulted solely from immobilization whereas the deficits on the cancellation test and on color discrimination were due to the combined effects of immobilization and the recumbent position

In addition to these measures, an appraisal was made of visual and auditory vigilance in one of the subexperiments The results were quite unexpected Performance on visual vigilance was better in the immobilized subjects relative to the two groups of control subjects Some indirect support for this finding is provided by Baker (1959) who reported that less active subjects tended to achieve superior performance on a visual vigilance task. On auditory vigilance, the performance of the recumbent controls was significantly poorer than that of either the ambulatory or immobilized subjects This finding is surprising because in an earlier study (Zubek et al, 1962) no significant differences in auditory vigilance occurred between recumbent and ambulatory subjects after a 1 week period There was however, a slight procedural difference In the earlier study, the recumbent subjects were not placed inside a box but lay on a mattress on the floor, a condition perhaps conducive to greater motor activity These results suggest the presence of a curvilinear relationship between performance on this measure and level of motor activity, i e, auditory vigilance is poorer under moderate levels of motor restriction than it is under lower and higher levels Curvilinear relationships are known to occur under other types of environmental conditions but in these cases the performance is usually better in the middle ranges An explanation of these divergent results together with the improvement on visual vigilance must await further research One possible confounding variable may be the complexity of the task which required prolonged attention to both visual and auditory signals during the vigilance

period Subsequent research employing both combined and individually presented vigilance tasks might throw some light on these perplexing results

Other studies Further evidence for the presence of a variety of behavioral deficits after prolonged kinesthetic deprivation was recently provided by the Russian investigators Gerd and Panferova (1966) A group of 19 male subjects were immobilized in a contour chair under a condition of normal visual and auditory stimulation for periods of 1½ to 19 days A wide range of tests was administered namely measures of two-point threshold kinesthetic sensitivity motor coordination visual motor responses attention associative learning arithmetical operations and memory for single concepts and coherent text materials Both simple and complex tasks were found to be impaired This impairment was attributed to the spread of cortical inhibition due to the inactivity of the motor centers The presence of a variety of intellectual deficits it is important to note was also observed in the 1 week Manitoba studies (Zubek & Wilgosh 1963 Zubek & MacNeill 1966)

In the only short term study Goldman (1953) reported that subjects who were strapped for 10 minutes in a special chair which prevented movements of the limbs trunk and head showed a significant increase in the duration of the autokinetic effect relative to a control condition Unfortunately no other perceptual processes were measured

Finally several animal experiments provide some support for the presence of behavioral deficits after immobilization Riesen (1961b) for example has demonstrated deficits of visual spatial performance in kittens and young primates who were merely restrained in bodyholders Although they were reared in a normal visual environment they were not permitted to move freely during such visual exposure" As in the Manitoba studies the impairments were differential Certain visual spatial responses were affected while others were not Deficits in learning ability can also occur following immobilization Using young rats the Czech investigator Czako (1965) reported a deficit in maze learning ability after 30 days of motor restriction

The results on adult animals are inconclusive Riopelle (1963) observed that rhesus monkeys released from total body plaster casts showed some perceptual as well as motor impairments Draper and Bernstein (1963) on the other hand reported that a 2 day period of immobilization of rhesus monkeys in total body casts produced only temporary motor deficits without any prolonged psychomotor impairment

In summary these results indicate that prolonged periods of kinesthetic deprivation alone can produce behavioral changes similar in a number of respects to those occurring after prolonged exposure to sensory and perceptual deprivation There are however a number of differences the most notable of which is on vigilance performance

SUMMARY

The first half of this chapter has been concerned with the sensory and perceptual motor effects resulting from an overall reduction in stimulation from several sense modalities The weight of the experimental evidence indicates that conditions of reduced sensory input do not produce a variety of dramatic and unusual distortions of the perceptual environment as reported initially from the McGill laboratory, at least as derived from qualitative observations. In addition to qualitative reports, a wide variety of objective measures of sensory and perceptual motor functions have also been employed. Studies of visual processes, which have been the most thoroughly investigated, have produced a differential pattern of results. Among the tests which are impaired are electrical flicker, Gottschaldt Embedded Figures, Bender-Gestalt, spiral aftereffect, figural aftereffects, reversible figures, Müller-Lyer illusion, phi-phenomenon, "perceptual lag," visual reaction time, and visual vigilance. Color perception is also impaired hut only after durations longer than a day. On the other hand, such visual measures as depth perception, the constancies, brightness discrimination, c.f.f., and visual acuity do not appear to be affected by either short-term or long-term deprivation periods An increase in visual functioning, as measured by a tachistoscopic recognition technique, can also occur but only after short-term deprivation.

Only limited attention has been paid to performance measures of modalities other than vision. These have also yielded a differential pattern of results Studies employing prolonged durations have revealed an improvement in auditory vigilance, a faster auditory reaction time, and increases in tactual acuity, pain sensitivity, and taste sensitivity. On the other hand, delayed auditory feedback and kinesthetic acuity are not affected whereas tactual form discrimination and tests of spatial orientation are impaired. In general, no consistent pattern of changes on nonvisual measures has been found to occur after short term deprivation periods.

The evidence clearly indicates that both simple and complex measures of visual motor coordination are adversely affected by sensory and perceptual deprivation. A similar effect can also be produced by social isolation alone provided that unusually long durations are employed.

The second half of the chapter has been concerned with the effects of single modality deprivation. The results indicate that visual deprivation alone can produce an increase in tactual acuity, pain sensitivity, auditory discrimination, and olfactory and gustatory sensitivity, effects which in most cases were still present 1 day after termination of deprivation. This would suggest that an overall reduction in sensory input from several modalities is not essential for the production of these facilitatory phe

nomena These results are significant in two respects First they suggest that some of the other effects produced by sensory and perceptual deprivation may also occur after visual deprivation alone Second these findings are of considerable theoretical significance since they seem to support the sensoristatic model of the nervous system recently formulated by Schultz

Research on the other modalities has indicated for example that prolonged periods of kinesthetic deprivation alone can also produce behavioral changes similar in a number of respects to those occurring after sensory and perceptual deprivation Furthermore it has been demonstrated that prolonged auditory deprivation can produce an increase in auditory sensitivity and prolonged tactual deprivation an increase in tactual acuity This latter effect appears to reflect the operation of central neural factors since the phenomenon can be demonstrated on the non deprived contralateral side of the body

Numerous variables can effect the magnitude and pattern of the sensory and perceptual motor effects during both short and long deprivation periods Among these are duration of isolation time of test administration after isolation type of deprivation condition ambient level of illumination in the test room type of subjects and whether the subjects succeeded or failed to endure a prescribed period of deprivation Of these perhaps the most important is time of test administration Increases decreases or no change in performance can occur with the specific effect being determined by the time of test presentation after termination of deprivation Another important variable is duration of the experiment A considerable body of evidence indicates that a 2 day period frequently produces greater behavioral changes than either a shorter or longer duration

8

Physiological and Biochemical Effects

John P. Zubek

The purpose of this chapter is to review the available scientific literature on the physiological and biochemical effects of sensory and perceptual deprivation and to relate the results insofar as possible to emotional motivational intellectual and perceptual changes already reviewed in the preceding chapters

Although numerous physiological functions have been studied the two receiving the most attention are changes in electrical activity of the brain and changes in galvanic skin resistance (indicator of physiological arousal) The emphasis on these two measures is perhaps not too surprising in view of the popularity of neurophysiological explanations of isolation phenomena Measures of circulatory respiratory and skeletomuscular activity have been employed in numerous studies but no consistent pattern of results has emerged particularly in the short term deprivation studies Little interest has been shown in biochemical changes Furthermore this literature is almost exclusively directed at the activity of the adrenocortical and sympathetic adrenomedullary systems

In order to present a more coherent view of the literature on sensory and perceptual deprivation the studies will be grouped into two categories viz those employing short durations (less than a day) and those using more prolonged periods This division is of some importance because the results from these two types of studies are not always in agreement Furthermore some doubts exist as to whether certain of the changes which occur after only a few hours can properly be attributed to reduced sensory input (Cameron Levy Ban & Rubenstein 1961 Jackson & Pollard 1962) In describing the various studies a differentiation will be made between sensory and perceptual deprivation as defined in chapter 2 This differentiation is again of some importance because the two conditions are not always equivalent in either their physiological or behavioral effects (Zubek 1964c)

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No attempt will be made in this chapter to review the extensive animal literature on the neurophysiological and neurochemical effects of sensory deprivation. An excellent review of this topic is available in a recent article by Riesen (1966).

PHYSIOLOGICAL EFFECTS

EEG Changes

Of the various physiological measures, changes in brain wave activity have been studied the most extensively. This research has been conducted not only in North America but also recently in a number of overseas laboratories located in England, the Netherlands, Russia, and Japan. Without exception, all of these laboratories have reported changes in EEG activity following prolonged periods of isolation.

LONG DURATION STUDIES

Duration of 1 to 7 days. Changes in electrical activity of the brain during isolation were first reported at McGill University in Montreal, Canada (Heron, 1957, 1961; Heron, Doane, & Scott, 1956). Daily records from six subjects who endured 4 days of perceptual deprivation revealed slow alpha waves of high voltage and marked delta wave activity, effects which were still present 3 hours after the termination of isolation (Figure 8–1). Further analysis showed a progressive slowing of EEG activity with time in isolation, i.e., more slow activity was evident after 4 days than after 2, in all subjects. This regular progression was still present even when the tracings were analyzed in 24-hour time blocks, a finding which suggests that the changes cannot be attributed to any chance variations in the sub-

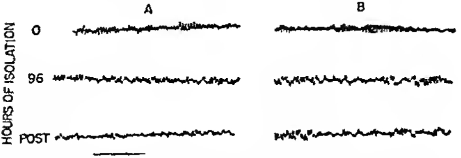

FIGURE 8–1 Typical sections of bipolar parieto-occipital tracings from two subjects, A and B. Note the presence of slower frequencies not only after 96 hours of perceptual deprivation but also three hours after emerging from isolation.

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ject's state of wakefulness which may have occurred at the time the records were taken. EEG tracings from one subject while hallucinating, showed "greatly reduced amplitude and appeared similar to those which might be obtained from a subject in an alerted state." The presence of more alpha-blocking in the hallucinating record is not easy to interpret. According to Heron (1961), it may either indicate that alpha blocking is a necessary concomitant of hallucinations or it may merely mean that the subject is attending to what he happens to be seeing. It is of interest, though, that the alpha activity which did appear was slower than that of the preisolation record. This slowing of EEG activity during isolation is attributed by Heron (1961) to a disturbance of the ascending reticular activating system (ARAS) resulting from a decrease in the level and variability of sensory stimulation.

An essentially similar pattern of EEG changes was observed in a British study (Smith, 1962). A group of schizophrenics were isolated for approximately two days under a condition of silence and unpatterned light. The "EEGs showed more widespread slowing after deprivation with theta and delta conspicuous. There was no paroxysmal or focal activity." Follow-up records revealed that these changes persisted up to an hour after termination of the 2-day isolation period. This slowing of EEG activity in schizophrenic subjects, interestingly, can also occur after brief periods of deprivation. Marjerrison and Keogh (1967) reported a decrease in occipital alpha frequencies in 18 male schizophrenics after only an hour of perceptual deprivation.

Slowing of electrical activity was also reported by two Japanese investigators, Nagatsuka and Kokubun (1964), who obtained continuous EEG tracings from nine subjects during 2 days of perceptual deprivation. The condition was similar to that at McGill except that motor activity was severely restricted by placing the subject in a special U-shaped bed. The EEG records revealed a "chronic continuum of middle slow waves of high amplitude . . . extremities of arousal waves and sleep waves appeared little." No evidence of a progressive slowing of electrical activity was seen; the pattern was essentially the same throughout most of the 2-day period. Follow-up records, unfortunately, were not taken. A slowing of EEG activity was also reported in two subsequent experiments employing 18 hour (Ohyama, Kokubun, & Kobayashi, 1965) and 24 hours of perceptual deprivation (Sato & Kokubun, 1965).

Undoubtedly the most extensive research on EEG changes has been conducted by Zubek and his colleagues at the University of Manitoba. The durations ranged from 7 to 14 days and conditions of both sensory deprivation and perceptual deprivation were employed. The first study (Zubek, Pushkar, Sansom, & Gowing, 1961) was exploratory in nature and involved the exposure of eight subjects to a week of sensory deprivation. A visual analysis of the "pre- and post-" EEG records, by an experienced

electroencephalographer revealed that two of the subjects showed normal post isolation records three showed a slowing of alpha by one or two cycles and three showed a slowing of the alpha together with an above average amount of slow or theta activity This theta wave activity was particularly noticeable in the temporal lobe region

In a subsequent 1 week experiment (Zubek & Welch 1963) a group of 40 subjects were employed ten in each of four conditions viz sensory deprivation perceptual deprivation recumbent control and ambulatory control EEG tracings were taken on an Offner eight-channel type T machine before and after each of the four conditions Ediswan monopad electrodes were placed on 18 areas of the head in International Federation 10/20 positions Scalp to average scalp to-scalp and scalp to-ear montages were employed In order to obtain a quantitative measure of EEG changes the mean occipital lobe frequency of each subject was determined according to the method of Engel Romano Ferris Webb and Stevens (1944) This involved counting by means of a Marshall EEG ruler the number of waves occurring in each of 200 1 second samples of artifact free occipital lobe tracings and dividing the total by the appropriate number to give the average frequency per second To avoid any bias the records were always analyzed without knowledge of the group from which they were drawn or whether they were pre or postdeprivation records

The results indicated that all 20 subjects in the two experimental groups showed a postisolation decrease in mean frequency with the decrease significantly greater under the perceptual deprivation (1 21 cps) than under the sensory deprivation condition (0 85 cps) On the other hand both the recumbent and ambulatory controls showed only negligible changes (−0 01 and +0 01 cps respectively) In addition to the changes in occipital frequencies the records of the subjects in both experimental groups were also characterized by an excess of theta wave activity particularly in the temporal lobes However the incidence of these waves appeared to be the same for both groups These results therefore clearly indicate that conditions of both sensory and perceptual deprivation can produce a disturbance of the electrical activity of the brain with the latter condition however exerting a greater effect This differential EEG effect may be related to the greater perceptual and cognitive impairments which seem to occur under perceptual than under sensory deprivation (Zubek 1964c) The fact that the recumbent condition did not affect EEG activity is also paralleled by an almost total lack of behavioral deficits under this condition (Zubek et al 1962) Thus there appears to be some correspondence between behavioral performance during isolation and the state of electrical activity of the brain

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ing performed significantly worse on various subtests of the Performance Scale of the Wechsler I Q test (e g Object Assembly test) than did psychiatric patients with normal EEG records Pollack (1963) has also noted that various psychiatric treatments which induce different degrees of EEG slowing are accompanied by deficits on a variety of verbal and perceptual motor tests Furthermore the magnitude of the deficits seems to be related to the degree of induced EEG slowing Finally Engel and Romano (1959) in a review article, stated that we have not observed any circumstances in which under experimental conditions diffuse slowing of the EEG failed to be correlated with an alteration in cognition or vice versa In the light of these data it is not surprising that the slowing of EEG activity which occurs during deprivation should be accompanied by various intellectual and perceptual deficits

One of the unexpected findings of the Manitoba studies was the presence of an abnormal amount of temporal lobe theta activity This involvement of the temporal lobes is significant in relation to an experiment by Baldwin Lewis and Frost (1957) who reported that chimpanzees subjected to a bilateral temporal lobectomy prior to 13 days of sensory deprivation exhibited none of the perceptual motor, and emotional disturbances which nonoperated control animals showed after the same type of isolation Furthermore the lobectomized animals were immune to the effects of lysergic acid (LSD) which in control animals produced striking behavioral changes These results indicate that some of the human deprivation phenomena e g certain perceptual changes may be reflections of disturbed temporal lobe activity a suggestion supported by the fact that the ictal patterns of temporal lobe epilepsy are sometimes characterized by disturbances of color shape size and depth (Kennedy 1911) Some of the hallucinatory phenomena too may have a temporal lobe origin Mundy Castle (1953) for example reported several instances in which vivid visual hallucinations evoked by photic driving were accompanied by high voltage irregular slow waves in the temporal and temporo-occipital areas

of social isolation also reported a similar phenomenon The change in EEG activity was always greatest toward the end of an experimental period regardless of whether its duration was 10 30 60 or 120 days *Table* 8–1 also indicates a progressive increase in mean frequency following termination of deprivation with indications of EEG abnormality still evident in several subjects 10 days after release from isolation Although these long lasting aftereffects may appear surprising some supporting evidence has been reported by Lebedinsky and his colleagues (1964) who observed indications of EEG abnormalities 2 months after the termination of a 2 month period of social isolation These results together with those of the Manitoba laboratory seem to suggest that certain physiological aftereffects may persist for periods equal to the isolation duration Some behavioral measures also show a similar relationship For example Zubek Flye and Aftanas (1964) observed changes in tactual acuity 7 days after termination of a week of visual deprivation

Another important finding was the existence of large individual differences with the mean decrease in frequency after the 14-day period ranging from 0 26 to 3 56 cps (see Table 8–1) Large individual differences were also present in the duration of postisolation motivational losses indicated by inability to study or to engage in a variety of activities These effects persisted from less than a day to 8 days (mean = 3 5 days) A cor

TABLE 8 1 *Mean Occipital Lobe Frequencies at Various Intervals During and After 14 Days of Perceptual Deprivation*

Subject	*During Deprivation*				*After Deprivation*			
	Day 0	Day 7	Day 10	Day 14	Day 1	Day 2	Day 7	Day 10
1	10 10	9 16	8 60	7 15	7 89	8 62	9 57	–
2	13 03	12 65	11 40	10 44	11 04	11.31	12 50	–
3	11 56	–	10 14	8 00	10 21	–	11 01	–
4	11 27	10 13	9 87	9 08	9 61	9 83	10 14	10 68
5	9 67	9 27	8 75	8 39	8 57	8 97	9 18	9 46
6	11 51	11 04	10 93	9 96	10 35	10 54	10 36	10 91
7	10 66	10 06	10 02	9 72	10 01	10 30	10 45	10 50
8	10 92	10 65	10 63	10 66	10 75	10 67	10 67	10 65
9	10 65	10 70	10 56	10 16	9 91	10 04	10 38	10 61
10	10 46	10 50	10 42	9 90	10 11	10 32	10 47	10 44
Mean	10 98	10 46	10 13	9.35	9 84	10 07	10 47	10 47

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relation of +0.67 was found to exist between the magnitude of the EEG decreases and the duration of the motivational losses. These results suggest that certain individuals are much more influenced by conditions of reduced sensory input than others, a finding also observed in some prison situations. Hinkle (1961), for example, reported that "under prison isolation as this has been carried out by Russian and Eastern European state police, most prisoners developed symptoms of disorganization within three to six weeks, but some have been known to endure this for many months, and some have succumbed within days." The reasons for these large individual differences are not clear. It is believed, though, that such factors as the subject's genetic makeup, personality, attitudes, and perception of the immediate situation may all play some role.

The magnitude of these EEG changes, can apparently, be influenced by the subject's expectancy or set concerning isolation duration. Figure

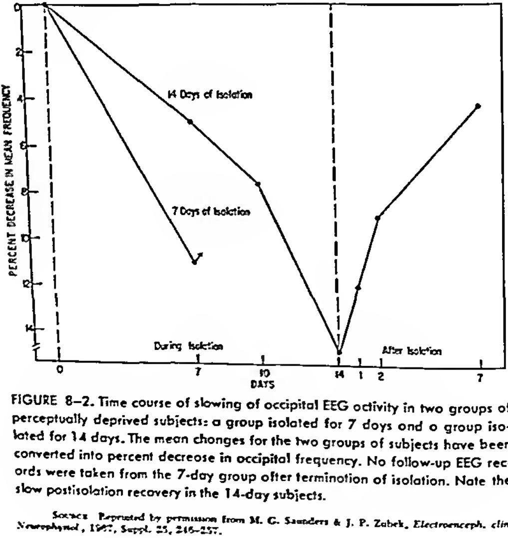


FIGURE 8–2. Time course of slowing of occipital EEG activity in two groups of perceptually deprived subjects: a group isolated for 7 days and a group isolated for 14 days. The mean changes for the two groups of subjects have been converted into percent decrease in occipital frequency. No follow-up EEG records were taken from the 7-day group after termination of isolation. Note the slow postisolation recovery in the 14-day subjects.

SOURCE: Reprinted by permission from M. G. Saunders & J. P. Zubek, *Electroenceph. clin. Neurophysiol.*, 1967, Suppl. 25, 246–257.

8–2 shows a comparison of the EEG changes in two groups of perceptual deprivation subjects a group isolated for a period of 1 week and a group isolated for 2 weeks All subjects in each group were informed beforehand of the duration of the experiment It can be seen that the 7 day group show a decrease of 11 percent in occipital frequency at the end of 7 days while the 14 day group only decrease by 5 percent over the same 7 day interval Furthermore an additional 5 days are required to attain the 11 percent decrease shown by the 7 day isolated subjects This phenomenon has also been observed by Lebedinsky Levinsky and Nefedov (1964) who reported that the EEG changes at the end of a 10-day social isolation experiment were considerably more pronounced than during the first 10 days of a two month experiment Thus preparedness or set for a given duration appears to be an important factor in determining the degree of EEG changes observed in isolation experiments Further research is required to clarify this phenomenon and the mechanisms underlying it

Soviet research on social isolation Several laboratories in the Soviet Union have recently investigated the physiological and behavioral effects of unusually long periods of social isolation (Agadzhanian et al 1963 1965 Gorbov Miasnikov & Yazdovsky 1963 Lebedinsky Levinsky & Nefedov 1964 Miasnikov 1964) Unfortunately the results are often described in the most general terms making an evaluation of their findings difficult The subjects are usually placed individually in either an altitude chamber or a space craft cabin for periods ranging from 10 days to four months Little or no intercommunication is maintained with them during the experimental period Apart from this restriction they lead a relatively normal life For example they are fed four times a day sleep for nine hours perform certain routine chores and take programmed tests at certain intervals Motor activity is usually restricted because of space limitations They are kept under constant visual surveillance either through a one-way screen or by a closed-circuit television system

Some of the findings were similar in many respects to those reported from the Manitoba laboratory The EEG records were characterized by diffuse slow waves or by a decrease in the alpha wave concomitant with a predominance of 4–6 cps waves interspersed with 0 5-2 cps waves (Agadzhanian et al 1965) Furthermore these changes were usually greatest towards the end of the experimental period regardless of its duration Large individual differences were also noted e g in one of the 15-day experiments the range of decrease of the alpha rhythm index was from 8 to 40 percent (Gorbov Miasnikov & Yazdovski 1963) Finally there were frequent reports of long term aftereffects consisting not only of changes in EEG activity but also of a reduced working capacity enhanced fatiguability change in sleep function weakening of immunal reactivity reduction in the functional potential of the cardiovascular system and a

decrease in efficiency of physical work . . . After the 60-day test, these asthenization phenomena remained for about two months" (Lebedinsky, Levinsky, & Nefedov, 1964).

A variety of procedures were found to be effective in reducing both the intensity and duration of these "asthenization" phenomena. Of these, the most effective were prior exposure to isolation, performance of a special set of physical exercises, certain work-cycles, engaging in "useful work," and the use of an enriched vitamin diet. Unfortunately, no details are given on the type of exercises and diet that were employed.

Role of motor activity. The importance of physical activity in determining the magnitude of EEG changes is further supported by research at the Manitoba laboratory in three studies employing different degrees of motor activity. In the first study (Zubek, 1963a), the subjects were exposed to a week of perceptual deprivation but with no restrictions on their motor activity. In addition, they were required to engage in six 5-minute exercises of a calisthenic nature each day. EEG records taken before and after the 7-day period revealed a decrease in mean occipital frequency. This decrease, however, was significantly less than that of a group exposed to the same condition but required to lie quietly (Table 8–2). These sub-

TABLE 8-2 Mean "Pre-Post" Differences in Occipital Lobe Frequencies Before and After Two Experimental and One Control Condition (30 Subjects, 10 in Each Group)

jects also showed less of an impairment on a battery of intellectual and perceptual motor tests than did the "no exercise" group. Thus increasing the level of kinesthetic and proprioceptive stimulation during isolation can ameliorate to a certain degree a variety of deprivation impairments. These results are not too surprising in the light of several reports pointing to the "powerful excitatory influence of somatic sensory excitation upon the reticular activating system" (French, 1960), a physiological system which several investigators have implicated in the production of deprivation phenomena (Fiske & Maddi, 1961b; Heron, 1961; Lindsley, 1961; Schultz, 1965). It is interesting to speculate whether isometric exercises would prove to be equally effective.

Procedures other than physical exercises may also prove beneficial in minimizing possible isolation effects, e.g., the administration of certain modern neuropharmacological agents. Although these chemical agents have not been tried on isolated human subjects, some of them have proven extremely effective in animals. Barnes (1958, 1959), for example, reported that chlorpromazine abolished almost all of the abnormal behavioral responses developed by rats and mice placed in isolation for many days. The use of a variety of vitamin enriched diets may also prove to be a fruitful approach, particularly in view of the Soviet research on the role of dietary factors in isolation.

The purpose of the next two Manitoba experiments (Zubek & Wilgosh, 1963; Zubek & MacNeill, 1966) was to determine whether EEG changes can be produced in subjects whose motor activity has been severely reduced by means of immobilization but who otherwise are exposed to a normal and varied sensory environment. In these studies volunteers were strapped down in a specially constructed box for one week (see Figure 7–12). The EEG records revealed a decrease in occipital frequency of approximately 0.60 cps after the week of immobilization. This change was significantly different from that of an ambulatory and recumbent control group after 1 week, but was not as great as that which occurs after either a week of sensory or of perceptual deprivation. Accompanying these EEG changes, certain intellectual and perceptual impairments were observed, but these again were not as extensive as those produced by either deprivation condition. Thus restriction of motor activity alone can produce a disturbance of both performance and electrical activity of the brain, but visual and auditory deprivation increase these effects to a significant degree.

Additional support for these EEG changes resulting from restricted motor activity is provided by two animal studies in which immobility was produced chemically by means of neuromuscular blocking agents. In the first, Gellhorn and Loofbourrow (1958, 1963) reported "slow group potentials" in unanesthetized cats immobilized by curare. In the second study (Hodes, 1962) immobilization by Flaxedil resulted in slow frequen

cies of high voltage and occasional sleep spindles Large individual differences were noted in the degree of slowing as well as the speed with which it developed after the injection Additional experiments indicated that the slowing of EEG activity was not due to the direct action of Flaxedil on brain activity but rather was an indirect result of the withdrawal of proprioceptive impulses to the cortex

These studies suggest that the level of kinesthetic and proprioceptive stimulation present during isolation may be one of the most important variables operating in sensory and perceptual deprivation experiments They also suggest that some of the apparently contradictory results in this area of research may be related to differences in motor activity A detailed specification of its level in future research seems to be indicated

Sleep deprivation and EEG activity A progressive slowing of EEG activity can occur in conditions other than prolonged isolation Bridger (1964) comparing the effects of isolation and sleep deprivation cited several studies in which slow wave activity increased with sleep loss This similarity was interpreted as indicating that the subjects in these two conditions are in a state analogous to borderline sleep A similar picture of EEG changes also occurs in cats and dogs deprived of sleep for several days (Feldman 1961) Some of these changes were still present 24 hours after the termination of sleep deprivation

SHORT DURATION STUDIES

Several investigators have studied the EEG effects of short periods of isolation of approximately 1 to 24 hours duration In one of these (Mendelson et al 1961) two subjects were exposed to 6 hours of perceptual isolation in a tank type respirator Two-minute EEG records were taken every 15 minutes The results showed large fluctuations ranging from states of light sleep and drowsiness to those of alertness It was further noted that periods of no verbal activity were in general accompanied by slower frequencies which increased during periods of verbalization These physiological changes occurring as a function of presence or absence of verbal activity indicate the importance of self-generated stimulation in determining patterns of EEG activity Leiderman (1962) also employing a 6-hour period of perceptual deprivation reported a slight decrease in the average alpha frequency in the postexperimental period when compared to the preexperimental period Pre post measures of percent time alpha did not differ appreciably Hanna Burns and Tiller (1963) who obtained EEG records from three subjects exposed to 4 8 and 24 hours of sensory deprivation reported that detailed analysis did not reveal any consistent trend in the frequency or amplitude of the potentials These essentially negative results obtained by both Leiderman and Hanna and his co-workers probably can be explained by the fact that their subjects had all received prior isolation experience on several occa

sions and hence because of possible adaptation showed little or no effect This interpretation is supported by several reports indicating that prior deprivation experience can minimize subsequent impairments of both a physiological (Lebedinsky Levinsky & Nefedov 1964 Leiderman 1962) and behavioral nature (Suedfeld Vernon Stubbs & Karlins 1965 Zubek et al 1962)

Significant changes in EEG activity can occur even with isolation periods of an hour s duration if schizophrenics are used as subjects (Marjerrison & Keogh 1967) They can also occur in normal subjects provided that the reduction in sensory input is unusually severe This was demonstrated in two Dutch studies In the first (Van Wulfften Palthe 1958 1959) a group of 25 subjects was required to lie inside a small closed cylinder placed on the floor of a totally dark and soundproofed decompression chamber Immobility was total except for some movements of the eyes and eyelids Total time spent in the cylinder was approximately 2 hours It was however divided into 3 equal time blocks During the first and third periods various tasks were presented over the communication system while in the second a condition of total isolation was maintained Continuous EEG records revealed the presence of low fast irregular activity during both of the partial isolation periods This was true for all subjects but two However shortly after the initiation of the total isolation period there was an abrupt alternation with low slow dysrhythmic activity in the theta and delta frequency In the second experiment (Van Wulfften Palthe 1962) the procedure was replicated with a sample of 58 subjects ranging in age from 18 to 69 years Essentially similar results were reported Most of the subjects showed repeated periods of low slow waves during an hour of total isolation Frequently this slow wave activity appeared within the first 10 minutes of the experimental session No information is given on possible age differences in EEG activity or on psychological functioning during the isolation period This is unfortunate because this is the only study in the isolation literature employing such a wide age range

Role of the body field dimension The pattern of EEG changes can be affected by the type of subjects that are employed This was demonstrated in a study (Cohen Silverman & Shmavonian 1962a 1962b) in which 35 subjects were given Witkin s rod and frame test which measures an individual s relative dependence on external visual and proprioceptive cues in perceiving spatial relations On the basis of performance on this test the sample was divided into three subgroups viz field or visually oriented body or proprioceptively oriented and a middle group whose perceptual scores fell between the first two groups Measures of EEG activity and of nonspecific (spontaneous) fluctuations in galvanic skin response (GSR) were then taken at various intervals during 2 hours of sensory deprivation The results indicated higher neurophysiological arousal in

the field-oriented subjects as indicated by an increase in mean beta wave count and a decrease in alpha count On the other hand the body-oriented subjects and those in the middle group showed decreased arousal as indicated by a decrease in beta count and an increase in alpha count A similar picture was obtained from the GSR measures of arousal state i e the field group showed high levels of activation throughout the experiment while the body group was activated at first and then relaxed as the experiment progressed

In a subsequent experiment an attempt was made to determine whether certain centrally acting drugs might alter the response patterns of field and body-oriented subjects The earlier study was replicated except that the subjects were given either a sedative stimulant or placebo capsule immediately prior to isolation The arousal pattern of both groups to the placebo was similar to that of the first experiment However the response of the subjects to the sedative and stimulant was different in that the field subjects showed a decrease in central nervous system activation and a more relaxed psychological state as the experiment progressed and body subjects showed alerting to the stimulant and mixed response to sedative Thus changing the internal state of the two types of subjects via drugs can alter their physiological response patterns to isolation

Arousal level and incidence of hallucinations Several investigators (Freedman & Greenblatt 1959 Ziskind & Augsburg 1962) have suggested that some of the dramatic deprivation effects such as hallucinations and disorganized thought processes probably occur while subjects are in a transitional state between drowsiness and alertness This claim has recently been tested in four experimental studies In one of these (Rossi Furhman & Solomon 1964) three volunteers were subjected to two 7 hour periods of darkness and white noise and one control period each 1 week apart Continuous measures of EEG activity and of rapid eye movements (REMs) were taken At random intervals occurring three times per hour a tone was sounded and the subject was required to describe his mental activity just *prior* to the onset of the tone These taped reports were then rated by judges on two five point scales and the results related to the level of EEG arousal occurring just prior to the onset of the reporting signal From Figure 8–3 it can be seen that the incidence of hallucinations and disorganized thought processes varies inversely with measures of level of arousal The relationship was statistically significant for both sets of data It was also noted that the hallucinations seemed to differ from typical dream imagery in that they were not accompanied by REMs and were not restricted to periods of light sleep REMs occurred in conjunction with seven of ten rated dreams and only one of nine rated hallucinations In a subsequent replication employing ten subjects Rossi Furhman and Solomon (1967) reported essentially similar results Of six rated hallucinations, three occurred during the sleep state two during drowsiness

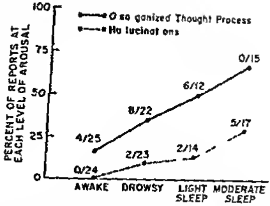


FIGURE 8–3 *Percentages of reports collected at each of four levels of arousal that were rated as d sorganized thought process or hallucination The denominators of the ratios above each plot point are the numbers of re ports with ratings reaching the cr terion of agreement be tween at least 2 of the three raters The numerators are the numbers of reports rated as disorganized thought process or halluc nation*

SOURCE Reprinted by perm ss on from A M Rossi A Furhman & P Solomon *Percept mot Skills* 1964 19 447–451

and only one was present during the awake state The incidence of disor ganized thought processes was also more prominent during lower levels of EEG arousal

Contrary findings have been obtained at two other laboratories. Leiderman (1962) in an exploratory study reported that complex imag ery occurred with equal frequency during either drowsy or waking EEG records The data were interpreted as indicating the presence of varying types of imagery some closer to dreams and hypnogogic states and others closer to the imagery of the eidetic and waking state Zuckerman and Hopkins (1966) on the other hand reported that visual hallucinations occurred almost exclusively during the waking state In this study con current records of EEG GSR and spontaneous reports of hallucinations were taken from 22 student nurses during an hour of sensory deprivation Of the ten subjects who experienced hallucinations sometime during the hour all but two reported them during a waking EEG record The results of these four experiments therefore seem to suggest that hallucinatory like phenomena can occur during both drowsy and waking states A more detailed discussion of this topic is provided in chapter 4

ANIMAL STUDIES

In conclusion a brief summary will be presented of some animal experiments in which the level of sensory stimulation has been reduced

surgically or chemically These studies in general, show an EEG pattern similar in many respects to that occurring in isolated human subjects

It has long been known (Bremer, 1935) that massive deafferentation produced by complete midbrain transection (the "cerveau isolé" preparation) results in high voltage, slow wave activity similar to one of the stages of sleep in the normal cat Recently, Villablanca (1962), using chronic preparations, showed that this pattern only appeared during the first 10 days after which both high frequency, low voltage waking patterns and slow, high voltage sleep rhythms were present These two patterns, which alternated for the next 2 months were closely correlated with behavioral wakefulness and sleep This return to essentially normal EEG activity was attributed to the "re establishment of homeostasis and in the lessening of shock like factors in the long term preparation

In addition to massive deafferentation studies, various workers have investigated the effects of loss of one or more sensory modalities Galkin and Speranski (1935) produced somnolent EEG patterns by destruction of the visual, auditory, and olfactory systems Arduini and Hirao (1959) reported slow wave activity in the occipital, parietal, and temporal areas following visual deafferentation Baxter (1959), on the other hand, observed a similar change in the visual but not in the somatosensory cortex Reduction of proprioceptive stimulation by neuromuscular blocking agents (curare type drugs) and by Sernyl also results in cortical slowing (Gellhorn 1958, Meyer, Greifenstein & Devault 1959, Randt & Collins 1960, Hodes, 1962) Finally, the Russian workers Beteleva and Novikova (1961) reported that even olfactory deafferentation can produce EEG changes This study is unique since EEG records were taken not only from the cortex but also from the brain stem reticular formation The results revealed a large decrease in amplitude and some slowing of the cortical rhythms in both the visual and sensorimotor cortex These changes were still present several months after olfactory deafferentation In contrast to the cortical records the results from the reticular formation revealed a pronounced increase in the "amplitude of slow waves (160 to 300 percent) and a greater prominence of fast oscillations These changes obtained from the reticular formation lasted 1 to 2 months after which the electrical activity returned to its original level This "exaltation effect is believed to reflect a raising of the level of excitability of the reticular formation and "can be explained by decline of cortical influences, the tone of the cortex being reduced by loss of olfactory impulsation

This Russian study is of considerable importance because it has demonstrated that reduction of sensory input (olfactory) can simultaneously produce a depression of cortical activity and an increase in activity of the reticular system This has not been reported previously Furthermore, if visual and auditory deprivation should produce a similar physiological difference the results may help to clarify some of the perplexing isolation

data in which both behavioral deficits and improvements have been observed For example the depression of cortical activity may be related to certain cognitive impairments (see chapter 5) while the increase in reticular activity might account for some of the improvements on a variety of measures of auditory cutaneous gustatory and olfactory sensitivity which are known to occur after prolonged periods of deprivation (see chapter 7) Although this hypothesis is highly speculative some support for it is provided by Fuster (1958) who reported that stimulation of the reticular formation in monkeys produced a faster reaction time and improved performance on a tachistoscopically presented visual discrimination task Lindsley (1961) has also shown that reticular stimulation can increase the resolving power of the visual cortex to two brief flashes of light In both experiments therefore improved performance resulted from increased activity in the reticular system

The presence of high amplitude slow waves in the reticular system can be seen not only after olfactory deafferentation but also during exposure of animals to several hours of darkness (Fox 1962) This type of EEG pattern however only appears shortly before a lever pressing response for a brief flash of light It does not appear midway between a burst of responses The significance of these results can only be clarified by future research

Changes in Skin Resistance

Changes in galvanic skin resistance (GSR) which are often taken as an indication of the level of central nervous system arousal of the subject have until recently received only limited attention In these studies two types of measures have been employed (1) basal resistance level which is believed to reflect the overall level of arousal or sympathetic tone and (2) the number of spontaneous or rapid transient drops in resistance (nonspecific GSRs) which seem to provide a more sensitive measure of moment to-moment changes in central nervous activity

LONG DURATION STUDIES

Three studies have investigated changes in skin resistance over a period of several days In the earliest of these carried out at Princeton (Vernon McGill Gulick & Candland 1961) GSR measures were taken from 18 subjects before and after 24 48 or 72 hours of sensory deprivation and from 18 controls at the same time intervals Because of the quiet and sleep-conducive condition experienced by the experimental subjects it was predicted that their skin resistance would increase since such an increase normally occurs in sleeping subjects This prediction was not borne out Regardless of duration all confined groups showed a decrease in resistance (greater arousal) and conversely all control groups showed an increase over the same intervals The decreases in the groups confined

for 48 and 72 hours were statistically significant as was the gain for the 24-hour control group. Follow-up measures taken a day after completion of the experiment did not differ significantly from the preisolation values. Because the skin resistance dropped progressively during the 72-hour period, the authors suggest that "longer confinements would lead to greater alertness than short ones."

In the second study, performed in Japan (Nagatsuka & Kokubun, 1964), continuous GSR records were taken from nine volunteers before and during 2 days of perceptual deprivation. The main finding was the presence of day-night rhythms with low arousal levels during the night and high arousal levels during the daytime hours. It was further noted that the arousal level was at its highest toward the end of the 2-day period, a finding in agreement with the Princeton data. A similar pattern of GSR changes was reported in a subsequent experiment involving a day of perceptual deprivation (Sato & Kokubun, 1965). However, in the absence of a control group in either study, these findings are difficult to interpret since day-night rhythms in GSR activity do occur under normal environmental conditions.

SHORT-DURATION STUDIES

Several groups of investigators have studied GSR changes during relatively short periods of isolation. Leiderman (1962) studied six subjects in four counterbalanced sessions, each of 4½ to 6 hours duration, and separated by time periods of 10 to 30 days. The conditions involved: vision and sound absent, vision and sound present, vision absent—sound present, and vision present—sound absent. Measures of GSR and heart rate, taken at 15- and 5-minute intervals, respectively, revealed no relationship to stimulus conditions. However, a high positive correlation was observed between GSR levels and incidence of imagery of a hallucinatory-like nature "perhaps reflecting, in part, its relationship to alerting as well as of autonomic nervous system activity." In a second experiment, 16 subjects were isolated for 2 hours under counterbalanced conditions of visual and auditory deprivation and vision present—sound absent. The physiological measures were again unaffected by the difference in conditions. Moreover, only a low correlation was reported between GSR levels and imagery. This lack of correspondence between the studies was attributed to the difference in the size of the samples.

Several investigators, on the other hand, have reported significant changes in GSR activity during short deprivation periods. Hanna, Burns, and Tiller (1963) subjected six volunteers to 4, 8, 12, and 24 hours of sensory deprivation. Electrical skin conductance (reciprocal of skin resistance) was monitored continuously during each session. The results revealed a decrease in skin conductance (decreased arousal) during the first 2 hours of all sessions (except 8-hour period), no changes or a moderate increase

for a number of hours and finally a pronounced increase in skin conductance (high arousal) toward the end of all sessions regardless of duration Furthermore a day night rhythm similar to that reported by Nagatsuka and Kokubun (1964) was clearly evident in the 24 hour session

The presence of decreased arousal during the early hours of deprivation has been confirmed by several groups of investigators For example Silverman Cohen Shmavonian and Greenberg (1961) and Cohen Silverman and Shmavonian (1962a) reported that most of their subjects exhibited decreases in skin conductance number of nonspecific GSRs and in mean *heart rate (all indicating decreased* arousal) during 2 hours of sensory deprivation They also observed that their field oriented subjects showed greater physiological arousal than did the body-oriented subjects on most of the measures Essentially similar results were reported by Nagatsuka and Kokubun (1964) who also observed a decrease in skin conductance and heart rate during the *first hour* of their 2 day experiment Subsequently however i e from 1 to 7 hours the pattern changed with both measures showing progressively greater arousal levels Duration therefore appears to be an important variable in determining the type of GSR changes which may occur during isolation

Another example of the role of duration was provided by Zuckerman Levine and Biase (1964) who obtained continuous skin resistance records from 36 female subjects confined for 3 hours to total isolation (no light—no sound) and to two conditions of partial isolation (light—no sound sound—no light) Figure 8–4 shows the changes in basal skin conductance over the 3 hour period It can be seen that there is little differentiation of the three groups during the first 1½ hours of the experiment However during the second 1½ hour period the skin conductance of the total isolation group rises *sharply* indicating greater arousal while that of the partial isolation groups remains level or rises only slightly Measures of nonspecific GSR reactions revealed a similar picture no differentiation during the first 1½ hours followed subsequently by a greater number of nonspecific reactions in the total isolation group Of the two partial isolation groups visual deprivation produced *more nonspecific GSRs during* the second 1½ hour period than did auditory deprivation Finally it was noted that the high GSR responders in total isolation were rated significantly higher on their need for activity and complaints of sensory deprivation than low GSR responders

In a further study Biase and Zuckerman (1967) replicated the previous experiment using male rather than female subjects An analysis of the combined data on the males and females revealed no significant sex differences in nonspecific GSR reactions but did show a significant effect due to conditions Furthermore the total isolation group showed the greater arousal and there was little differentiation between the visual and auditory deprivation conditions Because these differences were not apparent

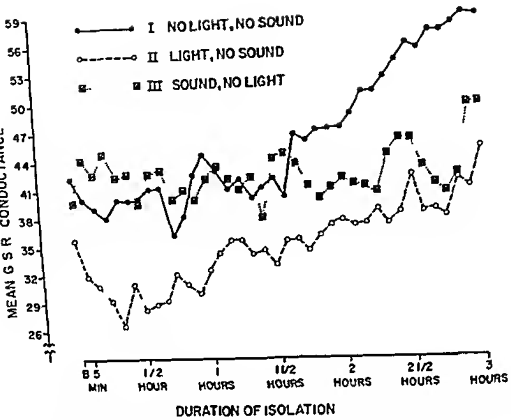


FIGURE 8–4 Changes in basal skin conductance during 3 hours of total and partial sensory deprivation

SOURCE Reprinted by permission from M Zuckerman S Levine & D V Biase *Psychosom Med* 1964 26 250–260

prior to the experiment or in the early part of the isolation period it would appear that they were due to the cumulative effects of sensory restriction in two modalities

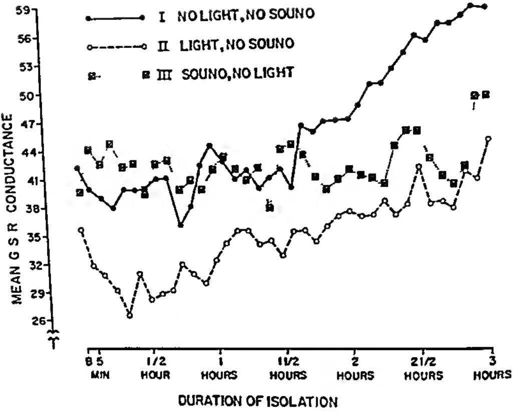
In a subsequent experiment employing *8* rather than *3 hours* of sensory deprivation Zuckerman and his colleagues (1966) reported no differences in either skin conductance or nonspecific GSRs between isolated subjects and a group of stimulation controls The control subjects were confined in the same isolation chamber as the experimentals but were exposed to continuous music and periodic changes of pictures on the outside window of the room These unexpected findings may have resulted from a lack of sufficient sensory variation in the control condition Another contributing factor may be the presence of social isolation If occasional visitors had been permitted in the control condition a clear differentiation might have resulted

In their final study Zuckerman and Haber (1965) wished to determine whether subjects who show a greater stress reaction (high GSR reactivity) to sensory isolation possess a greater need for stimulation than do those who are not so stressed by isolation The subjects who

were selected on the basis of their high or low GSR reactions to a prior isolation experiment, were tested in a second 3-hour sensory isolation condition. On this second occasion, however, they were given an opportunity to make an operant response which would produce random visual or auditory stimuli depending on their choice. The results revealed that the high GSR reactors made almost four times as many responses to brief visual and auditory stimuli as did the low reactors during the 3-hour period of total isolation. Furthermore, all of the subjects responded more for visual than for auditory reinforcement. These findings therefore clearly indicate that high GSR reactors have a greater need for sensory stimulation ("stimulus hunger") than do low reactors. Data of a somewhat parallel nature were reported by Vernon and McGill (1960), who observed that subjects who were unable to endure 3 days of sensory deprivation spent approximately 14 times as much time responding to a brief visual pattern during the first day than did those who endured to the end.

Variables affecting GSR and other physiological measures. GSR reaction patterns can be influenced not only by duration and type of subjects employed but also by several other variables. One of these is pre-isolation information (Culver, Cohen, Silverman, & Shmavonian, 1964). Subjects who were told in advance about the duration of isolation (2 hours) and the nature of the experiment showed fewer nonspecific GSRs (less arousal) than did the subjects who were not given this information. Measures of heart rate, respiration, and finger volume were not affected. An even more important variable seems to be the task demand placed on the isolated subject. Stern (1964) assigned 20 volunteers to each of two conditions of sensory deprivation. In one condition they were required to lie quietly, while in the other they were asked to report the direction of "movement" of an autokinetic light (the Vigil group). Various autonomic and skeletomuscular changes were continuously monitored before, during, and after 1 hour of sensory deprivation. The Vigil group showed a significantly greater increase in skin conductance and made more nonspecific GSRs (both indicating greater arousal) than did the Rest group. They also exhibited a greater increase in mean heart rate and breathing amplitude. Measures of muscle potentials (EMGs) and breathing rate did not differ significantly. Thus, the Vigil group showed a higher level of physiological activity on all autonomic indices except breathing rate, a finding which supports Duffy's (1951) and Malmo's (1959) hypotheses concerning the importance of task difficulty in determining level of physiological activation. On the basis of these findings Stern concludes that, at least for short-term studies of sensory deprivation, the task required of a subject, be it explicitly stated by the experimenter or inferred by the subject, is equally as important as the sensory environment.

A third variable is the degree of social interaction permitted during isolation. Its importance was demonstrated in a study (Shapiro, Leiderman, & Morningstar, 1964) in which 84 female subjects were confined for



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40 minutes, alone and in groups of three, in counterbalanced order During each condition they were required to participate in a guessing game Continuous recordings revealed that the group condition was characterized by a higher level of galvanic skin potential and a lower mean heart rate Moreover, the individual s physiological response pattern was much more consistent or more stable in the group situation than when alone A significant order effect, particularly for heart rate, also appeared

Exploratory studies In addition to these major investigations, two studies of an exploratory nature have been reported In one (Cohen, Silverman, Bressler, & Shmavonian, 1961), four volunteers underwent 4 hours of sensory deprivation Two of them were previously diagnosed as schizoid personalities the other two as well integrated These latter two subjects, who were quite upset during the experiment, showed higher levels of arousal on their GSR records than did the two schizoid personalities who reported being comfortable during isolation No mention was made of the amount of the difference In the second study (Ruff, Levy, & Thaler, 1961), continuous GSR records were taken from five isolated subjects confined for periods ranging from 1 to 20 hours Large individual differences were noted with some subjects showing consistently low arousal levels while others showed either high levels or periodic fluctuations in arousal state These differences in arousal patterns were closely related to the subject s affective state during isolation

Other Physiological Changes

Although considerable attention has been devoted to changes in EEG and GSR activity, little interest has been shown in other physiological measures such as blood pressure, respiration metabolic rate, body volume, and muscle potential activity Furthermore, the research that has been done has not always provided a consistent pattern of physiological effects

LONG DURATION STUDIES

In one of the early McGill studies (Heron 1961) several physiological measures were recorded from six subjects during 4 days of perceptual deprivation Oral temperature and blood pressure were taken twice daily and the basal metabolic rate each morning The results indicated no consistent changes in the subject s temperature or blood pressure and their basal metabolic rates remained constant Certain physiological measures however, do change providing that unusually long durations are employed This was demonstrated by the Russian investigators Agadzhanian, Bizin Doronin, and Kuznetsov (1963) in subjects who were socially isolated for a period of 60 days Table 8–3 shows the results for two of the volunteers It can be seen that both respiratory rate and blood pressure decrease progressively during the experimental period On the other hand

TABLE 8.3 Changes in Heart Rate, Respiration, and Blood Pressure During 60 Days of Social Isolation

Day	Heart Rate (Min.)		Respiration (Min.)		Blood Pressure	
	1st Subject	2nd Subject	1st Subject	2nd Subject	1st Subject	2nd Subject
10	49	66	15	10	113/53	115/60
20	49	61	15	10	110/50	109/53
30	58	69	12	9	109/47	110/50
40	56	65	10	8	104/50	110/51
50	56	73	10	9	105/48	109/51
60	59	74	9	8	107/48	105/51

SOURCE: Reprinted from N. A. Agadzhanyan, L. P. Bizin, G. P. Doronin, & A. G. Kuznetsov, *Zhurnal vysshei nervnoi Deiatelnosti Pavlov*, 1963, 13, 953-962.

heart rate shows an increase. Unfortunately, no data are provided for the preexperimental period.

Additional physiological data are provided by the Japanese investigators Sato and Kokubun (1965) and Nagatsuka and Kokubun (1964) who obtained continuous tracings of heart rate, respiration, muscle potentials, and GSR during 1- and 2-day periods of perceptual deprivation. The results for heart rate are shown in Figure 8-5. It can be seen that the results follow a W-shaped pattern during the two-day period with the two troughs of low heart rate coinciding with the night-time hours and the three peaks of high heart rate coinciding with the three day-time periods. Similar day-night rhythms, though not as marked, were seen on the respiration, muscle potential, and GSR measures. Since similar rhythms occur in a normal environment, it was concluded that functions relating to the autonomic nervous system are little affected by perceptual deprivation (Kitamura & Ohkubo, 1964). However, in the absence of a control group this conclusion can only be regarded as suggestive.

Physical changes. Decreases in body weight almost invariably occur during prolonged isolation. For example, the Japanese investigator Kitamura (1964) reported a loss in body weight of 5.7 lbs after 2 days of perceptual deprivation, while Myers, Murphy, Smith, and Goffard (1966) reported an average weight loss of 4.5 lbs after 4 days of sensory deprivation. Control subjects, on the other hand, showed a slight increase in average weight. Kitamura also noted an increase in mean height of 11 mm.

Losses in body weight in almost all subjects were also observed at the Princeton laboratory (Vernon, 1963; Vernon, McGill, Gulick, & Candland, 1961). The average weight losses at the end of 1, 2, 3, and 4 days of sensory deprivation were 2.7, 1.8, 3.0, and 3.7 lbs, respectively, a finding

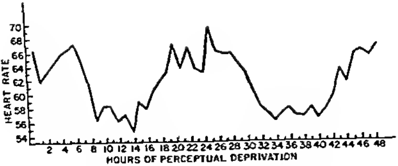

FIGURE 8–5 Changes in mean heart rate during 48 hours of perceptual deprivation Note the day night rhythms

SOURCE Reprinted by permission from Y Nagatsuka & O Kokubun *Tohoku Psychologica Folia* 1964 22 57–63

which suggests that the length of confinement is not necessarily directly related to the loss of weight Follow up measures revealed that these losses were regained almost entirely within the first day of release from isolation

These weight losses observed at the Princeton Laboratory, were unexpected since an oversupply of food was always present and the subjects ate well sometimes more than normal since it was an activity which helped to break up the boredom Although they ate well almost all of them seemed to derive no pleasure from eating In view of these weight losses their strength of grip was measured with a hand dynamometer The results revealed no significant differences between experimental and control subjects after either 1 or 2 days of isolation However after 3 days the isolated subjects showed an average decrease in strength of grip of 4 percent whereas the controls gained on the average about 8 percent It is doubtful whether this loss of strength of grip can be attributed to the decrease in body weight The decrease was only 3 lbs which could hardly be expected to affect the strength of an individual Vernon (1963) suggests that the data may merely indicate that weight and strength behave in a similar manner when subjected to sensory deprivation

Decreases in body weight also occur during prolonged periods of social isolation of 10 days to 4 months duration (Lebedinsky Levinsky & Nefedov 1964) Their magnitude and range however is dependent upon whether or not the subjects participated in such experiments for the first time In persons who had earlier participated in chamber tests the reactions usually took place with lesser change

SHORT DURATION STUDIES

Although various physiological processes have been measured during short term deprivation no consistent pattern of results has emerged Davis

(1959) recorded heart rate finger volume respiration and muscle potentials from 22 control subjects and 28 volunteers exposed to an hour of sensory deprivation In general the isolated group showed increased muscular and circulatory activity and decreased respiration a pattern characteristic of anticipation of stimulus Contrary results however are reported by Hanna Burns and Tiller (1963) who observed a decrease in heart rate blood pressure and respiratory rate during the first few hours of either 4 8 12 or 24 hour periods of sensory deprivation These measures remained steady for the remainder of all four durations except toward the end of the 24 hour session when a sharp increase in heart rate occurred Decreases in pulse blood pressure and respiratory rate also appear in subjects who have undergone several hours of underwater isolation (Shurley 1960)

On the other hand some investigators have reported few if any significant differences between isolated and control subjects For example Culver Cohen Silverman and Shmavonian (1964) noted no changes in heart rate respiration and finger volume after 2 hours of sensory deprivation Silverman and his colleagues (1961) employing the same duration and condition also reported no changes in respiration and finger volume but did note a significant decrease in heart rate Finally Zuckerman and his colleagues (1966) observed no significant differences in GSR heart rate and in breathing amplitude during 8 hours of sensory deprivation relative to a stimulation control condition However the isolated group did show a consistently lower breathing rate throughout the experimental period a finding noted in some but not all of the previous studies

Thus no consistent pattern of circulatory respiratory and muscular changes seems to emerge from the short term deprivation studies This can probably be attributed to the wide procedural differences which exist among the various investigations

Interaction of drugs and sensory deprivation Although numerous studies have investigated the changes associated with either reduced sensory input or with lysergic acid diethylamide (LSD) only one has attempted to investigate the physiological and behavioral interaction of these two conditions (Cohen 1961 Cohen & Edwards 1961) Ten volunteers who had never received hallucinogenic drugs previously were studied at weekly intervals under each of four conditions (2 hrs) in random sequence LSD with or without sensory deprivation and placebo with or without sensory deprivation The original hypothesis that isolation would intensify the LSD state was not supported by the subjective reports or the physiological data On the contrary most of the subjects reported and all of the physiological measures (heart rate respiration finger volume GSR and EEG) indicated a marked attenuation of the LSD state during the 2 hours of sensory deprivation It is interesting to note though that soon after termination of isolation they began to feel the effects of LSD A different picture however emerged from isolated vol

unteers familiar with the LSD state through previous experience Their subjective response was one of 'considerable intensification' of the LSD reaction Unfortunately, no physiological measures were taken from these sophisticated subjects Cohen and Edwards (1964) interpret these differential results as indicating that a 'higher level of sensory input is necessary for unsophisticated LSD subjects before the emotional ideational, and perceptual alterations will occur'

This reduction of the hallucinogenic state in naive isolated subjects has also been observed with Sernyl (phencyclidine) by several groups of investigators (Cohen Luby, Rosenbaum & Gottlieb, 1960, Lawes, 1963, Luby et al, 1962, Smith, 1962) All have commented that the striking subjective phenomena experienced with Sernyl alone were either very much reduced or completely absent during isolation Pollard, Bakker, Uhr, and Feuerfile (1960) also found that the Sernyl effect was reduced by sensory deprivation but that the psilocybin and LSD effects remained unchanged Finally, the Chilean investigators Munez and Marconi (1966) reported contradictory results in an exploratory study using two subjects In one subject, a brief period of sensory deprivation had a potentiating effect on the LSD symptoms while in the other it had no effect

BIOCHEMICAL EFFECTS

LONG DURATION STUDIES

Two experiments have investigated the activity of the adrenocortical and sympathetic adrenomedullary systems during prolonged perceptual deprivation particularly to determine whether isolation may be classed with other stress situations which are known to produce biochemical changes The earliest of these was conducted at McGill University (Murphy Kurlents Cleghorn, & Hebb, 1955) Urinary measures of 11 oxycorticoids were taken from nine subjects before and during 1½ to 6 days of perceptual deprivation No control subjects were employed Because no consistent increase in the excretion of corticoids occurred, it was concluded that under isolation the adrenal cortex is not activated to a greater degree than it is by the minor exigencies of everyday life However, because these subjects were resting much more than normal, it is conceivable that recumbent controls confined with some perceptual distractions may have shown a decrease in corticoid output during the same interval (Zuckerman 1964b) It is known for example that certain urinary constituents such as adrenaline and noradrenaline are decreased during recumbency (Sundin 1958 Euler, Luft & Sundin 1955) Thus, relative to a recumbent control group an increase in corticoid output may have occurred

The activity of the sympathetic adrenomedullary system also appears to be unaffected by prolonged perceptual deprivation This was demon

strated by Zubek and Schutte (1966) in a recently completed study. In this experiment, daily urinary measures of catecholamines (adrenaline and noradrenaline) were taken from 31 male volunteers during a week of perceptual deprivation as well as for 3 days before and 2 days after confinement. A further 24-hour urine sample was taken from some of the subjects approximately 6 months after termination of isolation. Of the 31 experimental subjects, 18 successfully endured the week of deprivation while 13 were unable to do so (mean duration = 56 hrs.). Because the recumbent position is known to decrease the output of catecholamines, particularly noradrenaline, a group of 18 recumbent controls were placed individually inside the chamber and asked to lie quietly for a week. Apart from the restriction on gross motor activity, their environment was kept as normal as possible. They were permitted reading material, use of a radio, and were frequently visited by the experimenters. Furthermore, the inside of the chamber was covered with brightly colored pictures. All control subjects had initially volunteered for the experimental condition.

Figure 8–6 summarizes the results on noradrenaline, the peripheral neurohormone of the sympathetic nervous system (Euler, 1956). It can be seen that both the successful and the unsuccessful experimental subjects (the "quitters") show a noradrenaline pattern similar to that of the recumbent controls. An analysis of variance revealed that all three groups showed a significant decrease in mean urinary excretion of noradrenaline during the experimental period relative to their "pre" and "post" experimental levels. None of the differences among the three groups, however, were statistically significant.

Figure 8–7 summarizes the results on adrenaline, which is the main constituent of catecholamines secreted by the adrenal medulla. Again there was no significant difference in mean excretion level between the successful experimental subjects and the controls relative to their pre- and post-experimental levels. Both groups showed a significant decrease in adrenaline while in the chamber. This decrease in adrenaline, together with that for noradrenaline as indicated in Figure 8–6, probably resulted from the recumbent position maintained most of the time by all of the subjects (Sundin, 1958; Euler, Luft, & Sundin, 1955). On the other hand, the "quitters," i.e., those who were unable to endure the prescribed week of isolation, were characterized by a complex pattern of changes. First, the adrenaline level during isolation was related to their endurance. The early "quitters," who terminated isolation within the first 2 days, showed an adrenaline excretion level similar to their preisolation (pre-day 2 and 3) or postisolation (post-day 2) baseline levels. The late "quitters," however, showed a significant increase in adrenaline after the second day of isolation but not during the first 2 days. A possible explanation of this difference between the two types of subjects may be that the early "quitters" terminated isolation at the first indication of discomfort and unpleas-

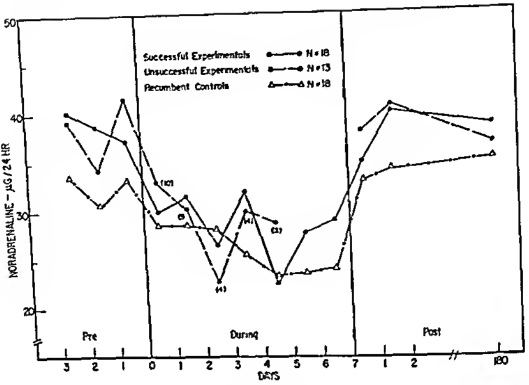

FIGURE 8–6 Urinary excretion of noradrenaline in two experimental and one control group before, during, and after a 1-week period The figures in parentheses refer to the number of unsuccessful experimental subjects ("quitters"), of the original group of 13, who remained in perceptual deprivation for a specified number of days, e g , only three subjects completed 5 days of isolation

SOURCE Reprinted by permission from J P Zubek & W Schutte *J abnorm Psychol* 1966 71, 328–334

antness and hence showed no increase in adrenaline, whereas the late "quitters stubbornly attempted to endure the entire week despite the stressfulness of the condition This interpretation is supported by the fact that the scores on a subjective stress scale (15 item Thurstone scale) were significantly higher in the late than in the early quitters

A second characteristic of the unsuccessful subjects as indicated in Figure 8–7, was the presence of a significant increase in adrenaline on the day *prior* to isolation and relative to preisolation days 2 and 3 A similar increase in preisolation noradrenaline level, although not as noticeable, can be seen in Figure 8–6 Further analysis of this phenomenon revealed that the "quitters who exhibited the greatest preisolation increase in adrenaline tended to terminate isolation the earliest The correlation, however, was not significant (Rho = −0 28) The presence of a high catecholamine level prior to an experiment has also been noted in other studies e g immediately before centrifuge (Goodall & Berman 1960) or drug studies (Elmadjian Hope & Lamson 1957) and is believed to be

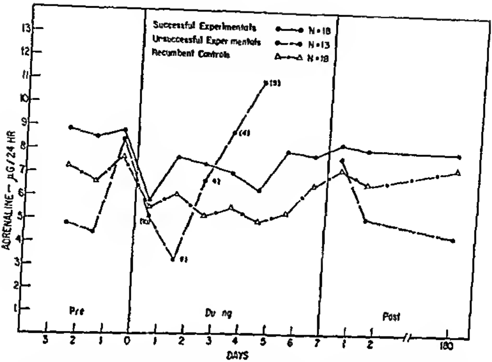

FIGURE 8–7 Urinary excretion of adrenaline in two experimental and one control group before during and after a 1 week period Note the pronounced apprehension effect shown by the unsuccessful experimental subjects on the day prior to perceptual deprivation

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indicative of apprehension about experimental participation This apprehension effect was clearly evident in the results of the subjective stress scale However contrary to what might be expected from the catecholamine data both the isolation quitters and the successful experimentals showed a significantly higher stress score on the day prior to the experiment and relative to the preceding 2 days

The third and perhaps the most important characteristic of the quitters was the presence of a preisolation baseline level of adrenaline (pre-day 2 and 3) which was significantly lower relative to that of the successful experimental subjects This low excretion level was also seen 2 days after termination of isolation as well as 6 months later Because this adrenaline baseline difference seems to be a stable characteristic persisting over many months it would appear that isolation quitters may be biochemically or constitutionally different from volunteers who can endure a prescribed period of prolonged isolation In view of these results further research is required to determine whether other biochemical differences may exist between these two types of isolation subjects

An analysis of the 24-hour urine volume of the successful experimentals revealed a progressive decrease in excretion during the week of isolation, a decrease significantly greater than that shown by the recumbent controls. This decreased urine volume was still present 2 days after termination of isolation but was back to normal 6 months later. No significant difference in total fluid intake of the two groups of subjects occurred during the 1-week period. A similar progressive decline in urine volume, independent of fluid intake, has also been reported by Winters (1963) in monkeys who were placed in darkness and silence for 14 days. Because water consumption was not reduced in either experiment, this decreased urinary volume may be a primary response possibly "triggered" by a greater production of the antidiuretic hormone of the pituitary gland. This suggestion of a possible pituitary disturbance is further supported by a recent study in which an increased production of the pituitary thyroid stimulating hormone occurred after 8 hours of sensory deprivation (Zuckerman et al., 1966).

In addition to the urinary measures, a daily appraisal was made of subjective stress and mood by two paper and pencil tests. The results revealed that the experimental subjects were characterized by a more negative mood and showed higher stress scores during isolation than did the recumbent controls. However, none of the differences were statistically significant except for the late "quitters" who showed a significant increase in stress score relative to the other groups of subjects. These results, therefore, closely parallel those of the biochemical determinations.

These results, together with the McGill data on 11-oxycorticoids, suggest that neither the adrenocortical nor the sympathetic-adrenomedullary systems are activated to any noticeable degree by prolonged periods of perceptual deprivation. Although isolation subjects may report a variety of affective disturbances, these do not appear to be reflected in the biochemical measures that have so far been employed.

Confinement in space cabin simulators. In general, few changes in adrenocortical and sympathetic-adrenomedullary activity seem to occur even when volunteers are confined for several weeks in space cabin and altitude chambers. These results are perhaps not too surprising because group rather than individual isolation is involved. Moreover, the subjects are often occupied by a variety of duties.

Tiller and Figur (1959) confined six subjects in a space cabin for a period of 8 days. The mean noradrenaline output during confinement did not differ from either the "pre- or post-" experimental period. Adrenaline increased but only in relation to the postconfinement measure. No change in total urinary catecholamines but a significant increase in 17-hydroxycorticosteroids (17-OHCS) was reported in two studies during 7 days in a space cabin (Celentano & Amorelli, 1963; North American Aviation, Inc., 1963). Ulvedal, Smith, and Welch (1963) obtained a variety of

urinary measures from four subjects before during and after 17 days of confinement No significant changes in adrenaline noradrenaline and 17 OHCS were reported There was however a continuous linear increase in corticosterone like hormones during the 17 day period An even longer duration was employed by Farrell and Smith (1961) Five subjects were confined in an altitude chamber for 30 days No changes in total urinary catecholamines and 17 OHCS occurred except toward the very end of the study when both increased sharply a phenomenon which may be related to the approaching termination of a very lengthy experiment

One of the important variables which can influence biochemical results appears to be the degree of intercommunication between the con fined subject and the experimenters The Russian investigators Gorbov Miasnikov and Yazdovsky (1963) reported an increase in 17 ketosteroids in subjects individually confined for 15 days in an altitude chamber under a condition of no intercommunication The largest increases occurred during the first 2 or 3 days However in experiments where some degree of *two-way communication was permitted* no changes in 17 ketosteroid output were observed (Udalov cited in Gorbov Miasnikov & Yazdovsky 1963) This finding is of considerable significance because it sheds a new light on the McGill and Manitoba experiments in which no changes in urinary corticoids and catecholamines were evident In both studies some verbal contact although infrequent was maintained throughout the per ceptual deprivation period If intercommunication had been totally eliminated an increase in the urinary substances may have occurred

Animal studies Certain biochemical changes have been reported in various animals isolated for prolonged durations Winters (1965) for example observed no changes in urinary 17 ketogenic steroids in four monkeys during 14 days of sensory deprivation Total catecholamine out put however increased by a factor of 19 during the first day of isolation indicating a considerable degree of emotional disturbance This might be expected because the animals were not only placed in a totally strange environment but also were restrained severely in a bodyholder This high excretion subsequently declined but did not reach the preisolation base line until the tenth day after which the level was maintained for the remainder of the isolation period Among the other changes was a pro gressive decrease in urine volume a finding also observed in the Manitoba catecholamine study

A variety of biochemical changes can also occur in isolated mice and rats For example Wase and Christensen (1960) reported a decrease in cerebral phospholipids and Defeo Guarino and Rosecrans (1965) a 50 percent increase in corticosterone after a month of isolation Changes in adrenal gland weight can also occur but the direction of change seems to be related to duration (Hatch Balazs Wiberg & Grice 1963) If animals are isolated for short periods (up to 10 days) they possess smaller adrenals

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than do control animals whereas if they are isolated for a month or longer they show larger adrenal glands These latter results provide an example of the lack of correspondence which often occurs between short term and long term deprivation effects

SHORT DURATION STUDIES

Catecholamine studies Although catecholamine output is not affected by prolonged isolation except in some of the "quitters" it appears to increase during short term deprivation Mendelson and his colleagues (1960) isolated ten subjects in a tank type respirator for periods ranging from 3 to 31 hours (mean = 9 1 hrs) The level of both adrenaline and noradrenaline during isolation was approximately twice that of the "pre and post" isolation control values This is a surprisingly large increase, particularly because the subjects were in a recumbent position which normally produces a sizable decrease in catecholamine output Two possible factors may account for the discrepancy between these results and those reported from the Manitoba laboratory First, severe restrictions on body movements were imposed in the Mendelson study Second, all of their subjects were "quitters" None of them were able to endure the prescribed period of 36 hours Thus an increased output might be expected These results therefore, appear to offer further support for the conclusion that prolonged perceptual deprivation can produce an increase in urinary catecholamines but only in subjects who terminate the condition prematurely

Cohen, Silverman and Shmavonian (1962a) using a much shorter deprivation period, found no consistent changes in urinary adrenaline and noradrenaline in 35 subjects during the 2 hours of sensory deprivation Increased catecholamine output, however, may occur even during these short durations if isolation is unusually severe This was demonstrated by Schaefer (1964) who immersed 18 volunteers for 3½ hours in a water tank placed inside a dark anechoic chamber Under these conditions both adrenaline and noradrenaline increased significantly These changes it is important to note, could be counteracted by a program of preisolation training In an exploratory study, six subjects were given a month's training in geometrical construction and projective geometry When isolated subsequently, they revealed no change in adrenaline and only a slight but not significant increase in noradrenaline They also showed a decrease in respiration and heart rate in contrast to the no-training group which showed an increase on both physiological measures Although these latter results are preliminary in nature, they seem to suggest that complex ideational activities performed prior to isolation may significantly modify the subsequent pattern of biochemical and physiological activity, and hence of behavior A possible basis for this counteracting effect of mental exercises may lie in a heightened cortical stimulation

of the reticular activating system (RAS) Lindsley (1961) for example has stated that arousal and alerting of the RAS are not solely dependent upon peripheral sensory influx but may equally well be produced by ideation and other cortical activity to past or present stimuli Presumably this heightened cortical activity was maintained during isolation and tended to compensate for the reduced sensory input

Other biochemical studies In addition to catecholamines several other measures appear to change during short term deprivation In one study (Zuckerman et al 1966) a variety of urinary and plasma measures were obtained from 14 subjects during 8 hours of sensory deprivation and 8 hours of a confinement control condition in counterbalanced order The urinary measures consisted of 17 ketogenic steroids (17 KGS) 17 ketosteroids (17 KS) and the luteinizing hormone the plasma measures comprised the pituitary thyroid stimulating hormone (TSH) adrenocorticotropic hormone (ACTH) hydrocortisone corticosterone protein bound iodine and thyroxine The results revealed a significant increase in 17 KGS and 17 KS during the experimental relative to the control condition Of the five plasma measures only the output of TSH showed an increase with all subjects but one showing this change

In a follow up study Persky Zuckerman Basu and Thornton (1966) employed a 24 hour period of sensory deprivation Contrary to their results on the 8 hour experiment they observed no significant differences between the isolated and confined control subjects on the output of 17 KGS 17 KS and TSH However a significant increase in output on the first two measures was seen in *both* groups of subjects relative to their output several months after the termination of the experiment The authors interpret these later findings as indicating that social isolation and confinement are the significant sources of stress in sensory deprivation experiments and that many of the effects attributed to sensory deprivation are really a function of the total isolation situation relative to normal life conditions This interpretation appears to be supported to some degree by the Soviet research described earlier in which certain physiological changes were observed in volunteers who were socially isolated for many days but were not subjected to any appreciable reduction in visual and auditory stimulation

In a further analysis of the data Persky and his co-workers compared the levels of 17 KGS and 17 KS observed during the first 8 hours of the 24 hour period with the results of the original 8 hour study For the sensory isolation condition the values were strikingly similar but for the confinement control condition the first 8 hour period values were considerably greater for both measures than those obtained in the original 8 hour study One possible explanation of these results offered by the authors is that anticipation of the remaining 16 hours of the experiment on the control day constituted a significant factor in itself This is a rea

sonable hypothesis, particularly because it is known that a subject's expectancy or set for a prescribed experimental duration can affect the results, e g the magnitude of changes in EEG activity

SUMMARY

A review has been presented of the physiological and biochemical effects of sensory and perceptual deprivation Of the various physiological measures changes in electrical activity of the brain have been investigated the most thoroughly An impressive body of evidence has indicated a progressive slowing of frequencies in the alpha range, an effect which can appear as early as 1 hour, provided that the isolation condition is unusually severe This change in electrical activity is greater during perceptual than sensory deprivation a finding which suggests that the critical factor is variation in sensory input rather than a reduction in level of sensory stimulation *per se* An increase in temporal lobe theta wave activity is also reported but its incidence is the same for both sensory and perceptual deprivation The slowing of occipital EEG activity is usually most pronounced towards the end of the deprivation period regardless of its duration Long lasting aftereffects may occur, particularly after prolonged periods of isolation In some cases these aftereffects persist for periods equal to the isolation duration Large individual differences are an important feature of the EEG records Some subjects show a considerable slowing of brain wave activity while others reveal an almost normal record even after several weeks of sensory restriction

A close correspondence was noted between behavioral performance and the state of electrical activity of the brain Both the behavioral deficits and the degree of the EEG changes are greater under perceptual than under sensory deprivation There is also a high correlation between the magnitude of the EEG decrease and the duration of postisolation motivational losses Further correlational studies have indicated that some of the dramatic deprivation phenomena such as hallucinations can occur during both low and high levels of EEG arousal Furthermore, it appears that certain perceptual deficits may be reflections of disturbed temporal lobe activity

stimulation can produce behavioral and EEG changes similar in many respects to those occurring during sensory and perceptual deprivation. The effect of restricted motor activity, however, is not as great as that seen during isolation. These changes in the electrical activity of the brain have generally been attributed to the disturbance of the ascending reticular activating system (ARAS), resulting from a decrease in the level and variability of sensory input arriving in the ARAS via collateral fibers from the sensory systems. Some physiological data, though meager as yet, appear to support this interpretation.

Another physiological measure which has received considerable attention is galvanic skin resistance, a measure which is often taken as an indication of neurophysiological arousal level. After an initial increase in skin resistance (lower arousal) during approximately the first 2 hours of deprivation, a fairly consistent decrease in resistance (greater arousal) is evident. This arousal level generally attains a maximum toward the end of the experimental period, regardless of its duration. The presence of day-night rhythms with low arousal levels during the night and high arousal levels during the daytime hours can be observed in deprivation experiments of several days' duration. However, the absence of GSR measurements during a comparable control period renders an evaluation of this finding difficult. Numerous variables can influence the pattern of GSR activity, especially in the short-term deprivation studies, e.g., pre-isolation information, type of subjects employed, duration of experiment, task demands during isolation, and the subject's affective state during the experimental period.

Measures of oral temperature, blood pressure, and basal metabolic rate are not affected during several days of isolation. Unusually long durations, however, produce decreases in respiratory rate and in blood pressure and increases in heart rate. Day-night rhythms in heart rate, respiration, and muscle potentials are reported, but their pattern cannot be evaluated in the absence of control groups. Decreases in body weight almost invariably occur during prolonged isolation. The magnitude of the decrease, however, bears little relation to duration. An increase in height has been noted in one study. No consistent pattern of circulatory, respiratory, and skeletomuscular changes seems to emerge from the short-term deprivation studies. Both increases and decreases in activity are reported. An attenuation of the hallucinogenic state in naive isolated subjects is produced by certain drugs such as lysergic acid and Sernyl.

Biochemical changes have received little attention until very recently. The results indicate that the activity of the sympathetic adrenomedullary system, as measured by output of adrenaline and noradrenaline (catecholamines), is affected little if at all by a week of perceptual deprivation or by prolonged confinement of groups of subjects for periods up to 30 days. Increased catecholamine output only occurs in some of the quit

ters", i.e., those who terminate isolation prematurely. An important characteristic of these "quitters" is the presence of an abnormally low baseline level of adrenaline both before isolation and also many months after its termination. This seems to suggest that isolation "quitters" may be biochemically or "constitutionally" different from volunteers who can successfully complete a prolonged period of isolation. Although catecholamine output is not affected during prolonged isolation, there are indications that short term deprivation can increase the level of both adrenaline and noradrenaline. These changes, however, only appear in isolation "quitters" or in those who have experienced an unusually severe condition of sensory deprivation (water immersion). This increase in catecholamine level, it is interesting to note, can be effectively counteracted by a pre-isolation program of "mental exercises."

The activity of the adrenocortical system, as measured by excretion of 11-oxycorticoids, 17 hydroxycorticosteroids, 17 ketogenic steroids and 17 ketosteroids also appears to be unaffected during prolonged periods of perceptual deprivation or confinement. Some of these results, though, seem to be dependent upon the degree of intercommunication existing between the confined subject and the experimenters. If such communication is totally absent, an increase in 17 ketosteroids can occur. Severity of the isolation condition, therefore, is an important variable. On the other hand, increased activity of the pituitary adrenocortical system can occur during short term deprivation of less than a day. The level of 17 ketosteroids, 17 ketogenic steroids and the pituitary thyroid stimulating hormone is increased significantly during 8 but not during 24 hours of deprivation, a finding which suggests that isolation may only be stressful early in the experimental period and not subsequently.

9

Tolerance for Sensory and Perceptual Deprivation

Thomas I. Myers

One of the intriguing features of research in sensory and perceptual deprivation (SD PD) is the considerable variation in individual reactions to an impoverished sensory environment Some subjects are anxiously upset as they withdraw from this condition while other subjects seem remarkably calm even unplaased by extended exposure to the very same condition To be sure the degree of endurance and other aspects of a subject s tolerance for isolation may be influenced by nondeprivation factors Among these are the subject s attitude toward an experimenter authority figure symbolic of his participation pledge his feelings of ade quacy in a situation frequently perceived as a test of manhood and other motivations including need for the remuneration usually offered Yet it is inconceivable to the present investigator witness to the behavior of more than 300 subjects in multiday SD conditions that the deprivation conditions are not the major determinants of these marked individual differences in coping with severe monotony This assumption seems to persist in other investigators as well even though in my judgment our understanding of these variations in response to a dearth of stimulation lags behind our knowledge of the general experimental effects of SD and PD Although the literature provides a number of promising approaches and some data to support them the mortality rate for prediction hypothe ses is notably high in replication studies At least no single linkage of per sonal characteristic to deprivation tolerance consistently accounts for a major portion of criterion variance

The serious student in SD and PD research must judge studies and perform many extrapolations to achieve any degree of closure The results from the various tolerance prediction studies require a special eyeglass one with automatic astigmatic correction Before summarizing these studies it may be useful to outline some of these methodological complexi

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ties Many of the points are applicable to deprivation research in general as well as to the state of prediction studies in particular

METHODOLOGICAL PROBLEMS

Variation in Method and Procedure

Experimental studies pertinent to tolerance are bewilderingly varied in motivational and set factors methods of sensory reduction and in such parameters as duration

The deprivation experiment is a tricky social psychological exercise for which subjects are somehow recruited to do nothing except to remain uncommonly quiet in a nonstimulating environment Despite the ingenuity of deliberately concocted cover stories to lend acceptable purpose to a study backed by undisguisable cost and energy the subject undoubtedly forms his own interpretation of what the study is all about Investigators in this area generally have shown a healthy awareness of the possible role of set factors although it is difficult to imagine any practical procedure that can entirely eliminate their influence The best indeed only answer to this problem is to seek findings that are replicable over experiments attempting in various manners to minimize such influences

Motivations for participating in a deprivation study vary and we know little of the consequences Most studies have been conducted in academic or medical research center settings using student subjects recruited on a paid basis Studies conducted under military auspices have employed servicemen receiving no special remuneration Personal curiosity and self testing are frequently mentioned reasons for participating Subjects in all studies are screened from a larger pool of potential subjects although the nature of the selection is rarely specified or even specifiable Students who receive and respond to a recruiting notice for part time work sometimes requiring an extensive block of free time may not be wholly typical students In one study of those who volunteered from a military pool the volunteer sample was biased with respect to certain life style measures e g high thrill seeking and lower phobic reaction which were also related (inversely) to endurance time in SD (Myers Smith & Murphy 1967) In another study MMPI scale scores of the nonvolunteer indicated his somewhat poorer mental health (Myers Murphy Smith & Goffard 1966)

The diversity of procedures for limiting the level and/or variety of sensory input is discussed at length in chapter 2 Bed confinement water immersion and respirator confinement have been the principal vehicles for producing a restricted sensory environment Visual stimulation has been homogenized through use of frosted goggles halved Ping Pong balls over the eyes or a Ganzfeld surround or eliminated entirely by complete

darkness External auditory cues have usually been limited by confinement in "soundproof" chambers or through use of masking noise Deprivation studies have varied a good deal in the extent of movement restriction from instructing the subject to limit voluntarily his activity to using coffin shaped devices which literally prevent movement In some cases tactual sensitivity is reduced by having subjects wear some form of a gauntlet or glove Each technique of deprivation has its adherents and the unanswerable arguments favoring and opposing each technique reflect the imperfect correspondence between deprivation as a general concept and any manner of engineering it For example the critic of the ostensibly superior hydro immersion technique may see immersion as potentially fear producing and any restraining techniques to effect extreme immobility may be viewed as productive of noxiously painful experience The reduction of effective stimulation is the concept common to all techniques and in my opinion there is little compelling evidence to suggest that mode of sensory limitation is overwhelmingly important If indeed there are many similarities of sensory isolation effects we can proceed toward a finer analysis of isolation tolerance without extreme concern about the deprivation method employed

Duration of Deprivation

Duration of deprivation is another parameter that has varied widely over studies The literature contains reports of sensory reduction ranging from just a few minutes to many days Many of these studies involve durations of 24 hours or less More prolonged multiday isolation was used in the McGill experiments early Princeton and Boston studies Manitoba Human Resources Research Office (HumRRO) and Naval Medical Research Institute (NMRI) studies The question most pertinent to this paper is whether or not tolerance measures obtained in short term and prolonged deprivation studies are measures of the same thing If affirmative then tolerance prediction studies of varied duration may be simply grouped together If negative then studies should be grouped with respect to duration because findings would necessarily differ Ideally our research task would be simplified if a face valid candidate measure of tolerance were (1) unaffected by increasingly prolonged duration or at least (2) clearly different at any duration from less varied sensory experience baseline(s) and hence a true SD or PD effect and (3) highly correlated within a deprived group over all stages and durations This structure would provide us with a unitary rapid onset phenomenon experimentally attributable to sensory impoverishment There would be no need to undertake the backbreaking and time-consuming logistics of prolonged confinement when a quasi waiting room situation would afford the same tolerance criterion There is a growing body of evidence on the

effect of SD PD duration, and on the SD PD vs baseline comparisons at various durations but there is still scant data on the predictability of later isolation states from early in isolation measures

First, the evidence on the effects of duration An adherent to prolonged deprivation research, such as the present investigator, might contend that the initial 1 or 2 days of isolation (without sleep restriction) does not produce for most subjects unpleasantness or tedium of a magnitude comparable to that of later stages of sustained deprivation Certainly far fewer subjects withdraw prematurely from isolation of 1 day or less than do so in multiday studies For example the completion rate for short term SD exceeded that for longer deprivation at NMRI (18 of 18 in 1-day SD vs 21 of 40 in 7-day SD, $p < 001$) Other common yardsticks spanning studies of varied duration have been few Most extensively used has been the Isolation Symptom Questionnaire (ISQ) devised for the HumRRO experiments and since employed in the Princeton, Manitoba, NMRI, and Albert Einstein laboratories Table 9–1 summarizes some of these unpublished results For each of the three principal factor analytically derived ISQ cluster scores[1] Tedium Stress, Unreality Stress and Positive Contemplation, there is no overlap between mean scores for four 24-hour or less SD groups and for the four multiday SD groups ($U = 0$ $p < 02$)

TABLE 9 1 Isolation Symptom Questionnaire (ISQ) Cluster Means from Eight Experiments Comparing the Sensory or Perceptual Deprivation (SD/PD) Condition with Various Ambulatory Control (AC) and/or Live in or Recumbent Control (RC) Conditions

Laboratory	*No of Subjects*			*Experiment Duration*	*I Tedium Stress*			*II Unreality Stress*			*III Positive Contemplation*		
	SD/PD	RC	AC		SD/PD	RC	AC	SD/PD	RC	AC	SD/PD	RC	AC
A Einstein	17	17	–	8 hr	48	46	–	24 >	16	–	24	22	–
A Einstein	12	12	–	24 hr	52	37	–	23	14	–	23	18	–
NMRI	18	12	35	24 hr	31	22	27	18	12	16	32	24	35
Princeton	26	–	13	24 hr	43 >	–	22	24 >	–	11	38 >	–	24
HumRRO	115	–	116	96 hr	58 >	–	25	34 >	–	9	48 >	–	33
HumRRO	56	–	82	96 hr	64 >	–	29	41 >	–	11	46 >	–	33
NVRI	40	20	30	168 hr	66 >	26	24	50 >	16	10	62 >	43	34
Manitoba	31	18	25	163 hr	54*	38>22		38*	27>12		48	44	31

> signif at p < 01
* signif at p < 05

The only study with which I am familiar which directly compares single and multiday SD is an unpublished one just concluded at NMRI Preliminary analyses show that 7-day SD produced significantly higher levels of ISQ symptomatology than did the 24 hour SD conditions (see means in Table 9–1) Thus it certainly appears that prolonged deprivation (relative to short term deprivation) elevates criterial symptom response, as well as the sheer rate of withdrawal from the SD condition

A second question concerns whether or not short duration deprivation might still evoke greater criterial response than nondeprivation of similar duration, and hence elicit behavior to be predicted that is definitely relevant to the notion of impoverished surroundings[2] Here the outcomes shown in Table 9–1 are mixed Twenty four hour SD at Princeton produced significantly greater ISQ symptomatology than that of a separate group of normal activity ambulatory control subjects Yet, the small differences between 24 hour SD confined but stimulated control, and ambulatory control conditions at NMRI were significant only when analyzed by a design using a subject as his own control And even the repeated exposure data from the Albert Einstein laboratory showed relatively little evidence of SD effects upon ISQ measures Not to be discounted is the possibility that specific criteria may have varying relationships

[1] The cluster scores of SD subjects have been found to be somewhat more highly intercorrelated (range 00 to 77 average 45) than were the cluster axes as defined by biquartamin rotation (range .20 to .36 average .28)

[2] Unless the criterion behavior observed under a deprivation condition is shown or assumed to be altered experimentally by impoverishment (or unless it is highly related to signal criteria so affected by impoverishment) the stimulus reduction trappings of a tolerance prediction study are quite superfluous In such an instance the R R relationships studied are no more relevant to deprivation than to the condition of more normally varied sensory input Such a study is only a nominal deprivation study It is impossible to evaluate many studies in this regard particularly those which lack any less sensory reduced baseline (e g., Goldberger & Holt 1961b) and it is a rare instance when predictive associations within the baseline condition have been reported (Zuckerman et al 1966)

Crucial to this point and to the entire deprivation research field is the definition of less sensory impoverished condition(s) Normal activity control subjects retain great freedom of sensory and social experience but are buffeted by everyday stresses and strains and may differ from sensory restricted subjects on such factors as diet climate and sense of experimental participation Currently popular control conditions confining the subject to the laboratory may hold these latter factors constant but it is difficult to provide sensory and social enrichment within the laboratory that might not also pall and constitute relatively invariant input Thus treatments regarded as controls e g confinement only recumbent position controls even social isolation etc may be partial deprivation conditions Thus there is no simple formula for calibrating degree of effective sensory input of experimentally defined conditions and deprivation may form a broad continuum of comparative monotony perhaps interacting with temporal duration In my opinion the Manitoba and NMRI ISQ data in Table 9–1 support the notion of intermediate deprivation and increased symptoms with duration for such controls living in the laboratory but with provisions for varied sensory and social experience That control subject confinement in the laboratory does not necessarily elevate symptomatic reaction is shown in the 7-day NMRI study where live in controls provided with such sources as TV and communication with a fellow subject were similar to ambulatory controls My guess is that the stimulus nutriment for NMRI recumbent control subjects was more sufficient than that afforded the Manitoba subjects.

to duration, and that there may be several discernible stages within prolonged isolation. Intriguing in this regard is the finding that one of the ISQ clusters, Positive Contemplation, was not a psychometrically coherent entity within 24-hour SD groups at Princeton and NMRI, although indices of homogeneity of its constituent scores were high for 4-day and 7-day SD groups in HumRRO, NMRI, and Manitoba experiments. Perhaps this is just a caprice of nature. Or it may indicate that this positive adaptation cluster does not stabilize as a measure of individual differences until a point in isolation somewhat beyond the 24-hour mark.

A third aspect of the duration question is whether indices of later or overall reactions to prolonged deprivation can be accurately anticipated by early-in-isolation measures. If so, then by extrapolation, similar indices can be secured from shorter duration studies with some assurance that they might approximate long-term isolation measures as tolerance criteria against which to test prediction hypotheses. Two studies have shown early stimulation seeking to be significantly related to subsequent endurance of multiday isolation. In the first study (Vernon & McGill, 1960), extent of viewing a geometric pattern in the first 24 hours of SD was inversely associated with completion of 3-day SD. In the second experiment (Smith, Myers, & Johnson, 1967), the amount of time listening to a 1-hour stock market report, accessible to subjects after 8 hours of SD, was negatively related to endurance of 7-day SD. Another early-in-isolation indicant of eventual endurance in 4-day SD was a relative low estimation of time passage during the first 4 hours of SD (Murphy, Hampton, & Myers, 1962). Finally, motor restlessness measured during the second day of a 4-day SD period was inversely related to completion, although no such relation held for day 1 indices (Smith, Murphy, & Myers, 1962). Although these findings cement something of a bridge between early reaction to SD and later tolerance measures, additional data would seem necessary before one can, on this basis, uncritically combine outcomes of short-term and long-term prediction studies.

In summary, it seems clear that increasing duration of sensory restriction heightens criterial symptoms on comparable yardsticks. In some instances, even short durations (1 day or less) may experimentally produce symptom elevation relative to less deprived baselines. On a scattering of measures, early isolation behavior was associated with endurance of prolonged isolation. Because there is evidence affirming both the similarity and dissimilarity of isolation phenomena over varying duration, it may be prudent to anticipate that prediction findings might differ in short-term and in prolonged deprivation studies.

Homogeneously Healthy Subject Samples

Another feature of many deprivation studies mitigating against the demonstration of powerful personality determinants of isolation tolerance

is the use of notably healthy experimental subjects In part, this presumed high standard of mental health could be the product of screening safeguards adopted at a time when it was unclear at best whether or not SD and PD might pose a serious health hazard to participant subjects In addition, some of the commonly "tapped" subject sources probably have built in screens which winnow and select those individuals of greater emotional stability The celebrated but sometimes derided college sophomore has demonstrated at least one year's successful adjustment to academia The military personnel subjects used in other studies have no less demonstrated stamina and staying power in enduring successfully the rigors of military training strange and alien to their civilian backgrounds Only rarely have data been obtained and presented about the broader subject populations serving in deprivation studies or about further sampling bias attendant to such things as the use of volunteers Such information from the HumRRO research program however, has clearly shown that the SD volunteer from an already healthy manpower pool differs from the nonvolunteer in the direction of superior mental health Data from more than 500 individuals show the average volunteer to be lower on MMPI scales Hs, D, Hy, Pd, and Pt and higher on a combat' aptitude measure comprised of ego strength and masculinity elements (Myers Murphy, Smith & Goffard, 1966)

The practical effect of sampling bias favoring the healthy is that many studies of deprivation tolerance (e g, those listed in Table 9-2) simply may not contain many individuals obtaining extreme scores Measures with mental health implications, such as the MMPI clinical scales, are just not pitted over a wide range of scores against the various isolation tolerance criteria Thus not too surprising are the relatively weak associations with personality measures observed in experiments employing no compensatory selection of subjects Of course some studies oriented toward specific hypotheses have overcome (or minimized) the good health 'problem by superimposed selection of extreme cases, e g, extreme introverts and extraverts or deviant field dependent or field independent subjects

Some Statistical Considerations

The muddy state of the tolerance-prediction literature may be due in part to the multiplicity of potential predictors and the conservatism of using conventional standards of significance over replications

The likening of the deprivation condition to "a life size, temporally extended projective test is startlingly apt (Goldberger, 1966a) Limited in action possibilities and in exteroceptive input, the subject is left to his own devices to pass the time in the intimate and inescapable presence of a consciousness state typically reported as unsupportive of directed thinking Enhanced vividness of imagery and dreams in deprivation, and

the virtual absence of alternative amusements, provide an ample screen upon which to project individualistically determined themes Although it is exceedingly difficult for an investigator to gain access to these idiosyncratic subjective states without risking intervening influences reflections of these states are hopefully present in concomitant changes in affect, restlessness and other behaviors found to be associated with intolerance of confinement By definition, a projective test is viewed in very different ways by different individuals By analogy, the SD and PD condition should also elicit varied reactions Many personality patterns life styles patterns of defense, or what have you may be affected by the inactivity and static sensory input of the deprivation condition In short different types of people may react adversely to impoverished surroundings but for different reasons Studies concerned with any single conceptual linkage between personality and deprivation tolerance may show disappointingly weak outcomes To demonstrate the variance contribution of a single predictor may be difficult if this contribution must be weighed against a residual variance including untapped true variation as well as error It follows from this multiple predictor speculation that more robust support for each hypothesis may be obtained when the experiment jointly employs some multiple hypothesis testing technique (e g , the multiple discriminant function used by Wright and Zubek 1966)

Still another possible source of seeming chaos in prediction studies is the conservatism inherent in the practice of demanding conventional significance, e g 05 level in each of several replications A simple extension of Stouffer s method (Mosteller & Bush 1954) for combining the probabilities obtained in several experiments (taking directionality into account) produces combined probabilities for 05 level replications numbering two three four, and five to be 01, 002 0002 and 00001, respectively To consider only predictors achieving significant results repeatedly is thus enormously conservative in the sense of discrediting tenable hypotheses Similarly, four studies obtaining consistent (but usually unreported) 30 level results would combine to the 05 level Of course, such a predictor would not in itself be a screening technique of practical value But our usual standards may prevent us from unearthing members of a multiple predictor variable group discussed above

TOLERANCE CRITERIA

The preceding discussion assumes some answer to the criterion question, i e what we mean by isolation tolerance Fundamentally this is a matter of definition and of agreement among scientists In principle there are as many candidates as there are measures of interest to scientists Many

have been used But to permit any useful comparison across tolerance studies using different criteria requires some generalized notion of tolerance based upon empirical or conceptual coherence of criteria There are some encouraging indications as to clustering of criteria in the essentially bootstrap lifting progression in deprivation research (Myers 1961c)

Endurance

Simple endurance time has been a popular measure of deprivation tolerance It is easy to score and possesses a certain face validity To its discredit is the possibility that nondeprivation factors (e g role relationships of subject to experimenter) may influence whether or how soon early release is requested from the experiment Moreover endurance time is an insensitive yardstick for short term deprivation (except under hydro-immersion conditions) A purely technical limitation resides in the information loss from a dichotomization necessitated by the appreciable number of tied maximum endurance scores obtained in many prolonged duration studies

These findings indicate that simple endurance times in isolation are closely related to many of the alternative behaviors often viewed as hallmarks of isolation, and hence that endurance may usefully serve as a single criterial index. The apparent multiplicity of symptom patterns measured by the three ISQ clusters each of which was also associated with endurance, suggests that there may be varying types of adverse reaction patterns in a sensory restricted environment against which to relate multiple personality predictors. Until these elaborations are carried out, however, we can certainly consider studies of endurance armed with considerable assurance that this tolerance index lies close to the heart of SD and PD symptomatology. Empirically endurance seems to define a "centroid" position among various tolerance measures, but cannot, of course portray their diversity as well.

Of course, this seemingly central role of endurance time within a larger cluster of criteria does not preclude the utility of other criteria used in the literature, e.g., affect change measures ratings of adjustment, etc. Rather, their bearing upon the larger criterion picture simply remains less well known. Nor does the frequent inapplicability of endurance time to shorter term isolation studies indicate, in itself, that studies of correlation with nonendurance criteria within them are without value in adding to our understanding of deprivation tolerance. But the sketchiness of empirical bridges from short term measures to prolonged endurance times and in some cases the lack of clear-cut treatment differences for short term deprivation criteria raise a question as to the commonality of the two types of criteria. Incidentally, stimulation seeking within the first 24 hours would seem to be the short term deprivation measure of strongest demonstrated relevance to prolonged deprivation tolerance (Vernon & McGill, 1960 Smith Myers & Johnson, 1967). And Zuckerman and Haber (1965) have shown stimulation seeking to be related to degree of nonspecific GSR reactivity in a prior short term SD condition although few of the activity style and personality measures obtained in an NMRI study proved to be correlated with stimulation seeking in single day SD (Smith & Myers, 1966). It seems advisable at present to keep a study's duration in mind when examining prediction findings and to consider at least in future studies the likelihood of multistage adaptations to which different personality concepts may be successively relevant. As an obvious example, the claustrophobic subject may early exhibit his intolerance of isolation even by avoiding voluntary participation (Myers Smith & Murphy, 1967).

PREDICTION STUDIES

Studies of the prediction of deprivation tolerance are readily classifiable into omnibus and specific hypothesis categories. An omnibus study

is one which presents data on a number of personality measures or other personal characteristics usually with little elaboration of *a priori* hypotheses A somewhat larger group of studies appears to focus upon explicitly hypothesized and tested linkages of personality to deprivation tolerance The plan of this chapter is to consider first the omnibus studies and then the more hypothesis-directed studies under the separate headings management of primary process and ego strength pain tolerance and perceptual satiation sex of subject neuroticism and anxiety introversion extraversion field dependence sensation seeking and activity needs early insolation predictors and various variables affecting tolerance No attempt will be made to summarize a rather lengthy literature discussing the topic in overview without empirical contribution (e g Kubzansky 1961b Kenna 1962 Miller 1962 Shurley 1962a Arnhoff & Leon 1964 Haggard 1964 Myers 1964a Zubek 1964c Zuckerman 1964b Goldberger 1966a)

Omnibus Studies

A tactic tantamount to a shotgun approach to differential tolerance of isolation is evident in reports from several of the major laboratories e g Manitoba and HumRRO whose primary goals (at least initially) centered upon the experimental derivation of deprivation effects Results from these multiple measure assessments will be summarized in this section with those portions pertinent to specific hypotheses also cited in later sections

Wexler Mendelson Leiderman & Solomon (1958) reported the rank order correlations of MMPI and Edwards PPS scores with endurance for 17 subjects placed in a tank respirator PD situation in one of the early studies of the Boston group Although none of the MMPI was associated with time in respirator four of the PPS measures did reach the 10 level or better Need Exhibitionism was negatively related to endurance whereas positive associations were found for need Affiliation need Succorance and need Nurturance However Kubzansky (1961b) has reported a failure to replicate these relationships in a later sample at the same laboratory in which need Autonomy emerged as a positive indicant

In another study of modest scope the correlates of quitting short of 24 hours in SD were investigated in terms of Cattell s 16 P F test scores (Arnhoff & Leon 1963a) Two scores Surgency and Protension were found to be associated with successful endurance at the 05 level yet the authors concluded that such an outcome could well be due to chance factors In another study Thurstone Temperament Schedule (TTS) scores of 2C 2 hour PD subjects were correlated with Isolation Imagery and Time disturbance measures (Leon & Frank 19CC) Sociability was found to be negatively associated with Isolation Disturbance and Imagery Disturbance while Vigorousness of motor activity was positively related to Time Dis-

turbance Of perhaps less direct relevance to our subject was the reported lack of significant relationship of 16 P F, MMPI, and Embedded Figures Test scores to whether or not visual imagery was elicited during a 10-minute exposure to Ganzfeld conditions (Stewart, 1965) In the same study, however, sensitizers as defined by the MMPI, more frequently than repressors admitted having considered terminating the experiment ($p < .01$)

Personality prediction data of massive proportions has come from Zubek's laboratory at Manitoba and from the research of Myers Murphy, and Smith at the HumRRO unit in Monterey, California The initial Canadian report by Hull and Zubek (1962), summarized the first order relationship of MMPI, Edwards PPS, Thurstone Temperament Schedule (TTS), and biographical questionnaire measures to successful completion of 7 days of SD and PD The Ns were 11 successfuls (of 16) in an SD condition, and 19 successfuls (of 30) in a PD condition Of the 40 predictor scores obtained on subjects in each study, the only association at the .05 level or better was the negative relationship of need Intraception to endurance of SD Results from pooling the two conditions also failed to reach conventional standards of significance Successful subjects were significantly more likely to be nonsmokers and watched television less than unsuccessful subjects and there were trends for successful subjects to own more books (.10 level), to read more (.20 level) and to be older (.10 level) than unsuccessful subjects

Subsequently, cases were cumulated over several years of research on the 7-day PD condition until a total of 90 male students had completed, 60 successfully, this experimental condition According to the report of Wright and Zubek (1966), only one of the first order relationships of personality scale to endurance was significant, namely, that successful subjects were higher on need Deference In a still later group of 31 subjects (18 successfuls) undergoing 7-day PD, none of the personality scores were significantly associated with prolonged tolerance of the PD conditions Impressed no doubt by the consistent failure of these respected paper and pencil measures of personality to significantly relate to PD tolerance, the Manitoba researchers inaugurated the use of the multiple discriminant function method of analysis (Wright & Zubek 1966) Using the first 90 PD cases as a base, this method produced that linear combination of 25 component variables which optimally differentiated endurance success groups From this process 45 (of 60) of the successful subjects and 23 (of 30) unsuccessful subjects were correctly predicted an overall performance of 75.6 percent correct classification Because this encouraging outcome was rooted in an optimization procedure the authors appropriately undertook a cross validation on a later sample of 31 PD subjects The previously derived multiple discriminant function weights were applied to the new data with the result that the success category of 22 of 31 isolation subjects

was correctly predicted a significant performance of 71 percent accuracy Thus, the application of a multivariate analysis technique to standard inventory personality measures has yielded a replicable significant differentiation of subjects on the PD endurance criterion for measures which had notably lacked substance as direct measures of that same criterion Not so apparent to this reviewer is the descriptive meaning or interpretation to be made of the measures within the combinatorial function The 7-day group was reportedly higher on F, Hy and Neuroticism index scores of the MMPI lower on Dominant and higher on Sociable scores of the TTS, and higher on Succorance and Exhibition needs of the EPPS But of course overconcern on the matter of interpretation smacks of ungrateful quibbling about secondary features of an outcome which seems to work! The very complexities driving one to a combinatorial analysis in the first place may preclude the emergence of a simply satisfying description

In the same 1966 report Wright and Zubek describe a less fortunate result using the multiple discriminant function for combining Rorschach measures obtained from the Buhler Lefever Diagnostic Sign List Although most impressive results were obtained in the originating post-dictive sample (100 percent discrimination with 25 variables 91 percent with just 31) a shrinkage to a chance level of 55 percent correct classification was obtained in the replication sample

Thus a best buy method for analyzing the role of certain standard personality inventory scores is signaled by these important findings from Manitoba The course has been charted for further cross-validations on the data from other laboratories through derivation of weights for tests widely shared over studies Though the degree of forecasting discovered is less than perfect the road to useful prediction of deprivation tolerance may lie in this direction And perhaps an even greater robustness of prediction may result from applying multivariate analysis techniques to multiple tolerance criterion measures A more subtle view of the criterial process to at least break endurance ties (e g through use of such multiple symptom covariants as the ISQ discussed above) could be of great value (Myers 1964c)

The HumRRO tolerance prediction data have come largely from subjects in 4 day SD conditions of darkness and silence (Myers Murphy Smith & Goffard 1966) although some not previously published data from earlier 6-day studies will also be presented In these initial runs 55 of 85 subjects completed the 6-day stay In two segments of the 4-day SD runs successful completers numbered 82 (of 117) and 29 (of 56) The test instruments administered throughout included the MMPI Edwards PPS and a biographical questionnaire Among the biographical characteristics long staying subjects tended to be older (05 level) and were more frequently nonsmokers (05 level) paralleling the Manitoba findings. Of no

apparent relevance to tolerance were such factors as birth order, educa tion and intelligence As was observed in the Manitoba data significant first order relationships of the scales to endurance were few and far be tween No 05 level differences at all were found for 6 day enduring subjects although a negative association with Hypochondriasis (06 level) and a positive trend for need Abasement (07 level) was found The pic ture sharpened slightly in the 4-day SD studies In the first of these experi ments subjects enduring 4 days scored high on need Deference (01 level) and need Affiliation (05 level) and low on need Aggression (02 level) Trends at the 10 level indicated that long staying subjects were lower on Psychopathic Deviancy Hypochondriasis and need Exhibition scores In the second 4 day SD series early release subjects were significantly higher on Hypochondriasis and Psychopathic Deviancy (02 and 05 levels) and showed 10 level trends toward higher scores on Depression and lower scores on need Succorance a somewhat scattered array

In an attempt to comprehend any possible low level orderliness in these findings the simple directions of differences for the three HumRRO experiments (and for the Manitoba PD studies by courtesy of Dr Zubek) were assembled in a table It soon became evident that an outcome stan dard requiring repeated significance at say the 05 level quickly converged on an absurdly low combined probability whereas by the same route con sistently repeated sub-significant trends would add up to a noteworthy result (even though lightweight in its variance contribution) The re sults of this inspection appear in Table 9–2 For each of the MMPI and Edwards scales is listed the endurance group long staying (L) or short staying (S) with the higher mean score The two Manitoba studies are so summarized without coding of significance level In the three HumRRO studies endurance subgroup symbols are underlined to denote 10 level relationships The combined probabilities from the three HumRRO studies reaching at least the 20 level (two-tailed) are listed in the adja cent column with indication of the higher scoring endurance subgroup For the HumRRO data four scales showed combined outcomes at the 05 level with four other measures falling in the 05 to 10 range High need Deference and Consistency scores seem associated with successful endur ance of SD joined by Affiliation need and the Social Responsibility (Re) scale Early release subjects scored higher on Psychopathic Deviancy and need Aggression and also tended toward higher values on Hypomania and Hypochondriasis Lending further unquantified support is the man ner in which directions within the Manitoba data line up with these find ings In both of the Canadian samples Deference Affiliation Psychopathic Deviancy and Hypomania show directionalities consistent with the HumRRO findings

The point raised earlier about the possible weakening effect of a sampling bias toward homogeneous good health upon the first-order rela

TABLE 9 2 Edwards PPS and MMPI Scales and Endurance in Five Studies of Prolonged PD/SD Listing the Group, Long Staying (L) or Short Staying (S), with the Higher Mean

Predictor Variable	*Manitoba PD Study*[1]		*HumRRO SD Study*[2]			*HumRRO Combined*		*Relation to Arctic Adjustment*[3]
	1	2	1	2	3	Sign	Level	
Edwards PPS								
Achievement	S	L	L	S	L			
Deference	L	L	L	L	L	001	L	Pos
Order	L	L	S	S	L			Pos
Exhibition	L	S	S	S	S	13	S	
Autonomy	S	S	S	L	S			
Affiliation	L	L	L	L	L	09	L	
Intraception	L	S	L	L	S			
Succorance	L	S	S	L	L			
Dominance	S	L	S	S	S			
Abasement	S	L	L	S	L			
Nurturance	S	S	L	S	L			
Change	S	S	L	S	S			
Endurance	L	S	L	S	L			
Heterosexuality	S	S	S	S	S			
Aggression	S	L	S	S	S	05	S	Neg
Consistency			L	L	L	05	L	
MMPI								
L	L	L	L	L	S			
F	L	L	S	L	S			
K	S	S	L	L	S			Pos
1 Hs	L	L	S	S	S	10	S	Neg
2 D	L	S	L	L	S			
3 Hy	S	L	L	L	S			
4 Pd	S	S	S	S	S	03	S	Neg
5 Mf	L	L	L	L	S			
6 Pa	S	S	L	S	S			
7 Pt	L	S	L	L	S			Neg
8 Sc	L	L	S	L	S			Neg
9 Ma	S	S	S	S	S	07	S	Neg
0 Si	L	?	L	L	L	20	L	
Es			-	S	L	20	L	Pos
Re			-	L	L	06	L	
MAS			S	S	L			
IR			S	L	L			

tionships outlined in Table 9–2 is germane The possibility is well illustrated in some preliminary data from our just completed 7-day study at NMRI using Naval enlisted personnel as subjects Supportive of the general tenor of Table 9–2 is the indication that 19 early release subjects had higher Ma scale scores than did 21 7-day SD subjects Even more interesting is the fact that 45 percent of the NMRI sample had "symptomatically high T scores of 70 or higher In the HumRRO experiments less than half of this proportion (22 percent) had scores of the same magnitude ($p < .01$) In this instance, at least, a sample containing a psychometrically suitable proportion of meaningfully high scores resulted in an association with endurance of SD ($p < .05$, two-tailed) much stronger than the trends found in previous samples with far fewer "high scores This development suggests that predictor measure findings may be sharpened by a superimposed selection of extreme scores in the larger N experiments of the past and future

The final column in Table 9–2 shows the .05 level associations between the scales and supervisor rated adjustment to work on the Arctic DEW line (Wright Sisler, & Chylinski, 1963) Although including the latter may be gilding an evanescent lily, it is interesting to examine the patterns across rows The positive indicators Deference, Affiliation Need, Ego Strength, and Social Responsibility garner some support from this inspection while negatively indicative traits Psychopathic Deviancy, Hypomania, Hypochondriasis and Aggression are also quite consistent

Clearly there are limits to the value of this picture of single variable relationships Even if some rough convergence can be sighted these weak findings are of more conceptual than practical relevance A gambler should win but not prosper when guided by this information But perhaps these data can provide some clue as to the dynamics underlying deprivation tolerance The high Pd, Ma, and Aggression pattern suggests a character type related to some of the hypotheses to be considered later (e g , thrill seeking impulsiveness), and the positive indicants suggest a kind of maturity and strength the measurement of which may prove more elusive Note also that the high Pd Ma type is often described as the person who busily engages in "acting out and manipulating others in his environment Although deprivation of these pursuits in monotonous solitude may genuinely "distress such individuals they are also the ones who might more freely challenge the rules of the confinement and feel more justified in exercising the early release option The distress of other types of persons more likely to play the game "by the rules may be poorly reflected in the endurance measure, which again recommends the potential of tie breaking criterial techniques more sensitive to the staying sufferer

In summary, the studies which load a shotgun with conventional inventory measures of personality have produced patterns distinguishable if at all only through (1) combinatorial equations predictive of endurance,

or (2) rough directional trends from many massive N experiments Depri vation intolerant subjects tend to be youngish television watching non reading smokers who score high on Pd Ma and Aggression scales Their more enduring counterparts seem to score a bit higher on some measures of mature responsibility such as Consistency Deference Affiliation Social Responsibility and Ego Strength A linear combination of inventory mea sures has shown a reasonably high robustness of prediction A greater use of multivariate techniques in the future seems clearly warranted Both in dividual and multiple measure prediction findings may sharpen percep tibly with a greater refinement of measures e g measurement of multiple intolerance typologies suggested by recent symptomatology studies

Management of Primary Process and Ego Strength

An early and influential conception of personality and deprivation in psychoanalytic terms was elaborated by Goldberger himself a pilot subject in the original McGill experiment in collaboration with Holt at the Research Center for Mental Health of New York University (Gold berger & Holt 1958 Goldberger 1961) Crucial to their notion is the psychoanalytic distinction between primary process and secondary process psychic functioning Primary process functioning is said to be dominated by primitive impulses (e g sex and anger) and possesses a pre logical character (e g shows condensation symbolization fragmentation loose or fluid associations autistic logic and logical contradiction etc) Secondary process a relatively drive autonomous rational mode of func tioning is said to be dependent upon contact with the structure of the external world The diminished reality contact intrinsic to the depriva tion situation facilitates the emergence of primary process thinking and the characterological key to deprivation tolerance is sought in individual differences in mode of handling it A measure of the effectiveness of con trolling primary process from Rorschach protocols has been detailed by Holt (1956) and Holt and Havel (1960) As used in their PD studies over all scores were obtained along a continuum ranging from effective con trol of primary process manifestations through an absence of primary process material (found in rigidly defended persons) to poorly controlled manifestations of the primary process (exemplifying a person with a frag ile defense system) (Goldberger 1961)

Two 8 hour PD studies were conducted at New York University In the first a total of 14 male undergraduates underwent an 8-hour PD ses sion involving halved Ping Pong balls over the eyes and a white noise auditory field (Goldberger 1959 1961 Holt & Goldberger 1959) During isolation subjects were required to verbalize concerning their thoughts, feelings and other experiences (upon signal if they did not freely do so) Extensive personality testing including the Rorschach preceded and an interview and cognitive testing followed isolation Ratings based upon

material of the isolation protocols interviews etc were rated in a number of categories (affective states thought processes imagery motor activity verbalization about quitting and self stimulational activities) and objective measures were obtained of verbal output sleep and of subject ratings of general disturbance Cluster analysis of these dependent variables produced two relatively uncorrelated syndromes A Positive Adaptation syndrome was defined by pleasant affect controlled primary process thought unimpaired secondary process thought self stimulation imagery immobility and verbal output A Negative Adaptation syndrome embraced unpleasant affect poorly controlled primary process thought quitting inefficient secondary process thought and general disturbance The Rorschach predictor measure of effective control of primary process showed a significant positive correlation with the Positive Adaptation syndrome and a strong trend toward a negative association with the Negative Adaptation syndrome In addition a large number of relationships were reported between other personality measures and the general syndromes and their constituent variables

The second New York University study was highly similar to the first except for the use of unemployed actors as experimental subjects (Goldberger & Holt 1961b) Again two general adaptation syndromes of reaction to isolation were obtained and judged to be similar to those obtained in the student sample but the Rorschach measure of effectiveness of control of primary process was seemingly not related to the syndromes in the actor sample The latter group moreover showed significantly higher overall incidence of primary process material on the Rorschach and according to the authors variance as well in degree and kinds of controls Relationships of the other personality measures to general syndromes and component dependent variables were highly similar in some cases (e g for ego strength) and also quite divergent in others (e g for masculinity vs femininity of interests) Although it is difficult to resolve satisfactorily such complex divergences the authors have attempted a higher order interpretation of adaptation and maladaptive patterns as related to the varying samples in question

The primary process conception seems to be a quite plausible one one that did not receive the evaluation it warranted in the New York University studies Use of an 8 hour session in the absence of a control baseline may or may not have been suitable to elicit PD attributable reactions of strength sufficient to provide clear-cut individual differences Also the method employed seemed to have placed a premium upon an individual s readiness to verbalize such that as the authors themselves noted both the Rorschach and the 8-hour PD situation functioned as projective test situations At least a more impressive test of the hypothesis would seem possible in a study of unequivocally severe deprivation whose

criterion measure of deprivation tolerance was not rooted in propensity to verbalize

Fortunately such were the features of a more recent experiment at Manitoba (Wright & Abbey 1965) These investigators used as a criterion the ability to endure 7 days of PD a treatment well known to affect many criterial behaviors (e g Zubek et al 1962 Zubek & Welch 1963 Zubek & Schutte 1966) Following the general procedure of Holt and Havel an index of effectiveness of control of drive-dominated responses was obtained as the ratio of Effectiveness of Defense to Defense Demand A chi square analysis of data tabulated according to Index of Control and successful or unsuccessful completion of the 7 day PD yielded a significant relationship in the positive direction All of the High Control subjects (7) were successful in PD 5 of 7 Middle Control subjects stayed 7 days and only 2 of 7 Low Control subjects endured the full PD period Although the Rorschach was administered several months after the PD experiment it seems unlikely that this post dictive timing of the measures would have markedly affected the outcome [3] The results of Wright and Abbey constitute impressive affirmation of the merit and applicability to SD and PD of the concept effectiveness of control of primary process

Leiderman (1962) has concluded from a pilot study of imagery in short term deprivation that those subjects with both the least amount of primary process material and best control of it have the most imagery and show the least body movement suggesting that body movement may be a better index of primary process and its control than are the reports of imagery In this connection one prolonged SD study has shown that restless movement measured on day 2 is predictive of endurance through day 4 whereas the reported visual sensations experienced seemed symptomatic for some subjects and an entertaining diversion for others (Myers Murphy Smith & Goffard 1966)

Two other studies are somewhat relevant to the question of how one manages primary process thinking Goldberger (1961) has frequently cited the relevance of Kris (1952) concept of regression in the service of the ego as descriptive of an adaptive and creative use of drive directed prelogical modes of experience Kubzansky (1961a) has reported a study on creativity as an index of capacity for constructive regression in relation to the imagery reported during 2½ hours of SD A positive relationship was found between Guilford test defined creativity and the number of visual images, and their clarity and complexity Finally a dissertation study by Goldberg (1961) explored the relation of adequacy of introspective coping skills and attitudes toward the self (as indicated by com

[3] These results were recently replicated at the Manitoba laboratory in a one week PD study employing 18 successful subjects and 13 quitters *In this unpublished experiment the Rorschach was administered prior* to isolation

material of the isolation protocols, interviews, etc., were rated in a number of categories (affective states, thought processes, imagery, motor activity, verbalization about quitting and self stimulational activities) and objective measures were obtained of verbal output, sleep and of subject ratings of general disturbance. Cluster analysis of these dependent variables produced two relatively uncorrelated syndromes. A Positive Adaptation syndrome was defined by pleasant affect, controlled primary process thought, unimpaired secondary process thought, self stimulation, imagery, immobility, and verbal output. A Negative Adaptation syndrome embraced unpleasant affect, poorly controlled primary process thought, quitting, inefficient secondary process thought, and general disturbance. The Rorschach predictor measure of effective control of primary process showed a significant positive correlation with the Positive Adaptation syndrome and a strong trend toward a negative association with the Negative Adaptation syndrome. In addition, a large number of relationships were reported between other personality measures and the general syndromes and their constituent variables.

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bined Rorschach and figure drawing scores) and intellectual efficiency and self ratings of adaptation in SD in Shurley s (1960) water immersion situation Although intellectual test behavior was not related to the personality measure individuals with poor introspective-coping skills and negative self attitudes indicated significantly poorer adjustment to SD

Incidentally in a study of measurement of openness to experience (subtitled A study of regression in the service of the ego) Fitzgerald (1966) has developed an Experience Inquiry questionnaire which may prove to be a simple and useful means of studying similar aspects of ego function relevant to deprivation conditions

Other deprivation studies have employed measures of ego strength a concept at least generally related to the Goldberger and Holt treatment of adequacy of defenses against the manifestation of primary process functioning The Barron Ego Strength (Es) scale of the MMPI was one of the few measures showing a sizable positive relation to Adaptive Reaction to Isolation in both of the New York University studies (Goldberger & Holt 1961b) The rank-order correlation was 61 ($p <$ 10 two tailed) in the student subject study and 71 ($p <$ 01 two-tailed) in the unemployed actor sample There was some trend in the last two HumRRO studies (see Table 9–2) for the Es scale to be associated with successful endurance of 4-day SD ($p <$ 20 two-tailed) About the same strength of relationship ($p <$ 30) is apparent in the just completed study of 7-day SD at NMRI

A report by Grunebaum Freedman and Greenblatt (1960) of clinically evaluated ego-integrity in relation to reactions to 8 hour deprivation has concluded that there was no relationship Among other observations of interest the authors described the behavior of two subjects with psychopathic tendencies who violated conditions of the experiment by removing goggles and earphones This nicely points up the possibility that personality of the subject itself may interact with the effective deprivation conditions if the ground rules of a given study allow leeway

Although not strictly research on deprivation tolerance an interesting study on personality changes after isolation treats various facets of ego function (Cooper Adams & Cohen 1965) The experiment showed that a 2 hour PD session produced in a varied psychiatric patient sample greater evidence of post PD improvement in certain measures of ego function than did a non PD control session Then it was shown that greater positive changes in one such criterion the Rorschach Prognostic Rating Scale (RPRS) was effectively predicted complete with cross-validation by a Defensive Style Index (designating subjects relying heavily on repression) and inversely by an Isolation Index (indicating subjects who tended to use isolation withdrawal and intellectualization as defenses)

Thus there are several leads of promise from considering adequacy of ego defense mechanisms and their patterning It is difficult to judge the commonality of the findings because there was great variation in the

criterion measures Although most of the research has used short term deprivation treatments the one prolonged isolation study carefully considering adequacy of defenses was quite successful in predicting endurance

Pain Tolerance and Perceptual Satiation

Another early hypothesis about isolation tolerance is that it is negatively related to pain tolerance (Petrie Collins & Solomon 1958 Petrie Collins & Solomon 1960) The deprivation experiments performed by Petrie and her co-workers however are largely concerned with perceptual satiation Subjects more enduring and less enduring of PD in the Boston tank type respirator differed at several test points in the degree of satiation of kinesthetic perception (the apparent size reduction of a block induced by the interpolated perception of a larger one) Greater satiation was observed in the less-enduring PD subjects A separate portion of the study showed higher satiation scores for other (non PD) subjects found to be most tolerant of pain Pain tolerance was defined as the highest temperature endured minus the temperature at absolute threshold Because satiation was negatively related to PD endurance and was positively associated with pain tolerance the authors inferred that pain tolerance is inversely related to PD tolerance For this to follow necessarily from the data presented would of course minimally require virtually perfect covariance in both substudies Petrie and colleagues further speculated that susceptibility to satiation may be in part the mechanism of intolerance (of PD) in that it would cause the limited stimulation available to be perceived as less intense (Petrie Collins & Solomon 1958) To my knowledge this interesting data on perceptual satiation has not been replicated although the abstract of a 1966 EPA paper by Minard (1966) states that Disappearance of an inspected square and kinesthetic after-effect predicted sensory deprivation tolerance and post deprivation depression increase A study by Francis (1966b) on tolerance of a loud tone also seems pertinent Subjects enduring relatively long in a water immersion experiment were found to be more tolerant of an increasing intensity of a 1 000 cps tone than were subjects with poorer endurance scores Neither absolute nor differential limen measures predicted deprivation endurance

A study by Peters Benjamin Helvey and Albright (1963) provided some follow up on the hypothesis of an inverse association of pain and PD tolerance Ministerial student and Air Force personnel subjects preselected on a composite measure of pain tolerance (muscular contraction electric shock and heat) were confined indefinitely to a contour couch in a space capsule cabin with sensory experience limited by white noise and translucent goggles In terms of hours stay in the cabin a direct association was found between PD endurance and pain endurance The authors concluded that the trend was nonsignificant in that only the extreme two

(high and low) of three pain endurance subgroups differed significantly by a *t* test One wonders whether a conventional one way analysis of variance might not have reached significance Significant or not, the association was a direct one, contrary to the Petrie hypothesis

In a related study of 7-day PD from the Manitoba laboratory, there was no significant difference between the mean pain threshold of 24 successful (7-day) subjects and 12 unsuccessful ones (Zubek, 1963b) Absolute pain thresholds were measured in this study, however, which may or may not be the same as the supra threshold pain tolerance measures used in the previous studies

In summary, one study finding perceptual satiation inversely related to PD endurance offered speculation about the possible negative relation of pain tolerance to PD endurance At least a trend toward the contradictory finding was obtained in a subsequent study of pain tolerance, and absolute pain sensitivity proved unrelated to PD tolerance in still another experiment

Sex of Subject

Of almost universal interest is the question as to how males and females compare in their tolerance of an impoverished sensory environment At least from common stereotypes it is reasonable to suppose that the sexes may differ in their reactions to a situation enforcing passive inactivity and in which daydreaming and fantasy characteristically displace directed logical thinking

A persistent problem in the study of sex differences in this area is that of gaining samples that are matched with respect to characteristics extrinsic to sex type This difficulty is well illustrated by the extraordinary experiment by Smith and Lewty (1959) Twenty subjects, 11 females and 9 males, underwent deprivation for an indefinite period in a silent room, wearing translucent goggles and gauntlets One of the unexpected results was that women in general seemed to last longer than men According to the calculations of this reviewer, a $t = 1.98$ and $p < .10$ was obtained for this sex difference in endurance But an even larger difference between samples existed on the Maudsley Medical Questionnaire Neuroticism (MMQ) scores The male sample had significantly higher MMQ scores than did the female sample ($t = 2.84$, $p < .02$) Finally, the sex difference in endurance times does not approach significance when one adjusts for this MMQ difference between sexes by the method of the analysis of covariance Thus from the data in the tables in the Smith and Lewty article, one can conclude either (1) that females tend to be more enduring in isolation (regarding group MMQ differences as consistent with sex typing), or (2) there is no sex difference in isolation endurance when neuroticism is appropriately controlled One can choose either outcome depending on whether one views males in this case hospital workers of

unspecified status as intrinsically more neurotic than females, in this instance nurses Actually the variables sex and neuroticism are not completely interchangeable in that the (negative) bearing of neuroticism upon deprivation tolerance can be demonstrated within each sex subgroup of their data (for males $r = -.84$ $p < .01$ for females $r = -.81$ $p < .01$) This reviewer at least would favor the neuroticism account of the apparent sex difference perhaps out of the sheer male ego These data not only illustrate the tricky nature of sampling for sex comparisons but reveal upon close inspection some impressive correlations of deprivation tolerance with the trait of neuroticism which were not highlighted by the authors of the study

Notable attempts to seek representative sampling of maleness and femaleness in other than biological terms were made in two studies from Shurley s laboratory (Walters Shurley & Parsons 1962 Walters Parsons & Shurley 1964) Proceeding from the research of Witkin et al (1954 1962) showing that females are more dependent than males on cues from the external surroundings to maintain orientation in their environment these investigators reasoned (1) that females (relative to males) would make more stimulus-bound than non stimulus bound observations in water immersion deprivation (2) that females would have the lower ratings of psychological content in postisolation interviews and (3) that sex of the interviewer would interact with sex of the subject in determining interview content The initial study used as subjects medical students matched in age education and socioeconomic background selected so as to separate male and female groups on Mf scale scores of the MMPI (Walters Shurley & Parsons 1962) The subjects in a follow up experiment were from a more varied population of individuals matched in age education socioeconomic background order of birth and spread by selection on the Mf scale The findings of both studies were contrary to expectation in that males exhibited greater tendency toward stimulus bound descriptions of their deprivation experiences Psychological content of interviews did not differ with sex in either study and the sex of experimenter and subject interactions observed were not consistent over studies

In an experiment by Pollard Uhr and Jackson (1963a) an 8-hour PD session repeated again after approximately one week has yielded data on the relative endurance of 12 male and 12 female college subjects screened for normalcy by interview and MMPI scores Contrary to the Smith and Lewty (1959) findings males more frequently than females completed the 8 hour PD condition (significance or not depending upon method of analysis) Eight males finished both (and two neither) of the sessions as compared with four females completing both (and seven neither) The two sessions were similar with nine males and five females completing their first and nine males and four females completing their second exposure to PD The number of self report responses and topics

were observed to diminish for the second session, but this may be as due to parallel decreases in verbalization of effects as to reduced occurrence of the effects *per se*

Two other studies of potential sex differences in responses to short term deprivation failed to find significant differences Arnhoff and Leon (1963b) found male and female college student subjects to react similarly to 2 hour PD in terms of Isolation, Time, and Imagery Disturbance measures In another study there were no sex differences in the number reporting movement, disturbance of orientation, or body image in a 20 minute PD session (Reed & Kenna, 1964a) The early 7-day SD experiments at Manitoba used as subjects four females along with twelve males (Zubek, Pushkar, Sansom, & Gowing 1961) Although the proportion enduring 7 days of SD is not reported for the two sexes, ' there were some suggestions that female subjects may be less prone to hallucinations than males Ten of 12 males and only one of four females reported them

An experiment by Zuckerman, Persky, Link & Basu (1968a) used both male and female college subjects in a research design comparing 8-hour sessions of SD, social isolation, and social confinement with a member of the same sex The authors concluded that ' females in SD tend to report more stress on the (ISQ) questionnaire than males and fewer sexual thoughts and positive feelings than males Their reactions to social isolation were quite similar In the social confinement condition, ' women expressed more affective arousal particularly hostility, somatic discomfort, and general stress than males when confined in pairs The reviewer finds this outcome difficult to interpret in its meaning for SD In general, there seemed to be relatively few differences among the three confinement conditions of this study, e g , on Tedium Stress and Unreality Stress (ISQ) cluster scores, a finding consistent with the two previous Albert Einstein studies of 8- and 24 hours duration (Zuckerman et al , 1966 Persky, Zuckerman, Basu, & Thornton, 1966) and the 24 hour SD study at NMRI as shown in Table 9–I Confinement *per se* seemed to be the major factor in this recent Zuckerman short term experiment, although this was not the case in the 24 hour NMRI study summarized in Table 9–1 In prolonged 7-day deprivation studies confinement produced ' partial deprivation like ISQ symptomatology in the Manitoba experiment, but had relatively little effect in the 7-day NMRI study This suggests that confinement is complexly defined and that the degree of sensory and social enrichment for the live in subject and treatment duration may be crucial considerations

In summary, there is little clear data at present to indicate that males and females differ in their capacity to endure deprivation One seemingly clear set of data can more parsimoniously be viewed as a case of confounded neuroticism whereas the other endurance data have tended to favor the males Nonendurance aspects of deprivation reaction related to

sex are suggestive male observations during deprivation seem to be more stimulus bound the occurrence of hallucinatory reports may be higher among males and females may react more to short term social confinement as well as to deprivation

Neuroticism and Anxiety

The impressively strong negative relation of MMQ neuroticism scores to deprivation endurance times in both female and male samples of the Smith and Lewty (1959) study was noted above These rank order correlations in the 0 80s suggest that neurotic anxiety state might be a strong determiner of individual reaction to a monotonous isolation situation supporting relatively few anxiety controlling mechanisms Phrased in this manner, the studies on effectiveness of ego mechanisms cited above are pertinent Other studies have reported the use of such measures as the Taylor Manifest Anxiety Scale (MAS) Maudsley Neuroticism and Welsh s Anxiety Index (AI) of the MMPI

Endurance of 7-day PD at Manitoba was not significantly related to Welsh AI scores (Wright & Zubek 1966) Nor did the Taylor MAS relate to completion of multiday SD in the HumRRO studies either in the separate experiments or in their combination (see Table 9–2) Also in the first HumRRO study there was no association between endurance and a measure termed Chronic Worry (Myers Smith & Murphy 1967) The Zuckerman group found that the Maudsley Neuroticism and MAS scales were significantly associated with a number of ISQ and interview measures of Stress Worry Thinking Difficulty and with such psychophysiological indices as nonspecific GSRs and heart rate However these relationships held about as well in the socially isolated stimulational control condition as in the 8 hour SD condition (Zuckerman et al 1966) Although these results show the relevance of normal anxiety level to appropriate types of reaction to isolation and confinement it is not entirely clear that the variances to be predicted were on measures that are especially deprivation related with the possible exception of Primary Process scores from the ISQ To my knowledge this is the only published study reporting baseline correlations of prediction measures to criterion behaviors in a non SD (or at least a less deprived) control condition In my opinion this technique of comparing correlations in deprived and less deprived treatments provides an extremely important control over extraneous sources of correlation e g responding styles It is recommended for use in deprivation tolerance studies whenever possible (But note its virtual inapplicability to studies using endurance times as a criterion because control group completion rates reach virtually 100 per cent) It is ironic that the excitement that might have greeted Zuckerman s correlations within the SD group had he not provided us with knowledge of those within the control group must be viewed as a sober

ing reminder of the shaky methodological foundations of so much of the deprivation tolerance literature

A somewhat more specific type of anxiety is evident in a measure of Dark Quiet Cell (DQC) Phobia used by the HumRRO researchers in their early 6-day SD studies It is based on questions concerning dislike of darkness extreme quiet, enclosed spaces, solitude, etc This instrument intended to tap facets of claustrophobic reaction was found to be inversely associated with willingness to volunteer for the SD experiment ($p < .001$) and among volunteers somewhat related ($p < .10$, two tailed) to inability to endure the 6-day SD (Myers Smith, & Murphy, 1967) A similar rationale seems to underlie the use by Zuckerman, Persky, Link, and Basu (1968a) of an Isolation Reaction Inventory (IRI), asking about normal life reactions to such situations as being alone, in darkness quiet, having nothing to do, etc IRI scores were found to be correlated with various affective reactions, such as anxiety, hostility, and depression, to 8 hours of being socially confined, but showed little association with response to SD or social isolation sessions of the same duration

Thus the box score on deprivation tolerance prediction studies using neuroticism and anxiety measures is a mixed one One study of indefinitely prolonged deprivation showed outstandingly high inverse associations of Neuroticism with endurance whereas trait anxiety indices in the Manitoba and HumRRO studies of multiday PD and SD showed very little A short term SD study, outstanding for its innovation of a control treatment baseline for correlations indicated that neurotically anxious individuals may behave characteristically on criterion measures even in a less-deprived situation raising some healthy skepticism about the extent to which other reported linkages of personality to response in SD may be due to normal life propensities A more specific anxiety measure concerned with dislike of many of the features of dark quiet isolation showed an inverse relation to volunteering for and endurance of prolonged SD, although a seemingly related measurement did not relate to response to short term SD

Introversion Extraversion

Another personality concept actively studied in its relation to deprivation conditions is that of introversion-extraversion In the first study concerned with this dimension, Tranel (1962) interpreted isolation phenomena such as hallucinations and daydreams as concomitant features of the process of introversion and hypothesized that individuals already on the extreme end of this dimension would be little affected by a sensory restricted environment Ten subjects selected from each extreme of a college student group on the Myers-Briggs Type Indicator (MBTI) were placed in a PD situation of 4 hours duration Nine of ten introverts failed

to complete the 4 hour PD as compared with two of ten in the extravert group This significant endurance finding thus contradicted the hypothesis that introverts would fare better in PD While in PD introverts adhered closely to the instructions tended to engage in stimulus bound thought and remained awake Extraverts in contrast tended to violate the instructions to engage in some form of pleasant reverie and to go to sleep Significant at the 10 level was the higher mean rate of movement during PD for the extravert group

Two Boston studies were concerned with introversion and PD During two 3 hour PD sessions introverts made more button presses for a promised time-off reward and scored higher on a discomfort index than did extraverts (Rossi & Solomon 1965) The significance of this difference is not clear A subsequent study was designed to resemble that of Tranel (Rossi & Solomon 1966) Extreme scorers on the MBTI proved to be similar in their endurance of 3 hour PD Seven of ten extraverts and eight of ten introverts completed the session Rates of visible movement were somewhat but nonsignificantly greater for the extraverts and ratings of well being did not differentially distinguish the two groups Introverts rated lower in well being *both* pre and post confinement—an important control! Among the differences in their procedures potentially responsible for this incongruence with the Tranel results a difference in MMPI profiles of the introvert and extravert samples of the two studies was noted

Two studies on introversion and brief PD have been reported from the University of Manchester Estimates of when 15 minutes had elapsed during a 20 minute PD period were significantly longer for Maudsley Personality Inventory (MPI) defined extraverts than for introverts supporting the authors expectation (Reed & Kenna 1964b) The eight (of 28) subjects reporting depersonalization experiences during a 26–60-minute PD experience were reported to have significantly lower MPI Extraversion scores (Reed & Sedman 1964)

Zuckerman et al (1966) also reported a variety of significant correlations of MMPI Drake Social Introversion (Si) and Maudsley Extraversion Scales with verbal and psychophysiological responses to 8 hour SD and 8 hour stimulational control conditions

The data from prolonged SD and PD studies summarized in Table 9–2 fail to show much relationship between MMPI Si scores and endurance If anything long staying subjects were slightly higher on introversion scores although it is doubtful that many extreme scorers were present in the relatively healthy subject samples used

Thus the data relating introversion to deprivation tolerance are unclear at best The significant findings reported favor the extravert as more tolerant although the study in question indicated that (reminiscent of the psychopathic subjects of Grunebaum Freedman and Greenblatt (1960) cited above) the extraverts more readily violated the experi

mental restrictions—e g , against movement—and may thereby have di minished the severity of the conditions

Field Dependence

The work of Witken et al (1954, 1962) has shown that individuals vary in the relative extent to which they depend upon external visual cues, as opposed to proprioceptive experiences, in perceiving spatial relations At the two extremes of perceptual orientation, the field dependent person relies mostly on the visual cues and the body-oriented (field independent) individual bases most of his perception on internal cues This typology (for simplicity, body and field types) is measured by reactions to a rod frame task pitting visual against proprioceptive cues in making judgments of the vertical, by a figure drawing task, or by speed-of response in perceiving the figures embedded within visual displays

The body field perceptual mode has been of interest to a number of investigators of behavior in isolation Because most deprivation situations rather effectively obliterate the visual cues basic to their perceptual mode the field-dependent subject would seem to be especially deprived in isolation Because interoceptive cues usually remain (in varying degree) in the deprivation situations, the more bodily oriented subject may undergo a milder degree of sensory impoverishment (Of course, it is conceivable that individuals placing a great premium upon *either* external or internal cue sources might be more disrupted by an environment altering both than would those individuals whose perceptual integrations are more ' balanced ')

Interest in the body field perceptual mode pervades much of the SD (and other) research undertaken by Cohen, Silverman, and Shmavonian at Duke University Illustrative is the experiment using 35 male ROTC students pre tested to determine their perceptual modes (Silverman, Cohen, Shmavonian, & Greenberg, 1961, Cohen, Silverman, & Shmavonian 1962a, 1962b, Shmavonian, 1964) Resting state urine was collected from each student after which he was led blindfolded into a dark sound attenuated chamber, where he was fitted out with electrodes for bioelectric measures, given a series of clinical neurological tests for sensory discrimination, and given progressively more intense electric shock to determine touch threshold and pain tolerance After being told that he would be left alone until the experiment was over, and that he should not talk or move, the subject was then left alone in the dark, quiet room for 2 hours During this period EEG, skin resistance, and vascular and respiratory rate records were obtained Following the experimental period the neurological and threshold measures were obtained urine was collected, and interviews and questionnaires were administered The results provided convincing evidence of differential reactions associated with perceptual mode Field types showed the greater peripheral auto-

nomic activation during SD as evidenced in nonspecific GSRs and greater EEG evidence of central nervous system activation Adrenaline and noradrenaline secretions did not differ however The field-oriented subjects were less accurate in their somatosensory discriminations initially and the difference was more pronounced post experimentally Four of the 12 field subjects demanded early release as compared with one of 11 bodily oriented subjects Discomfort scores were somewhat higher in the field group and predominantly anxious emotional states were ascribed to 10 of 12 field subjects but to only 2 of the 12 body subjects Anger prevailed in 9 of the body subjects and only two of the field subjects

Clearly the field dependent subjects exhibited greater anxiety toned activation than did body (or middle mode) subjects in 2 hour SD Yet one cannot help but wonder whether giving shock and attaching electrodes just prior to isolation might have fostered an apprehension contributing to this effect But here as in most of the studies reviewed there was no less-deprived control as a baseline to tell us whether the effects seen necessarily required the SD environment The Duke researchers are careful in their statements of attribution but it is easy for others to confuse the inferential status of behavior observed in SD with behavior due to SD

Use of the Duke experiment as a point of departure for discussing the possible influence of nondeprivation factors in studies of isolation tolerance is not intended as a singling out of this study for particular criticism The authors have deliberately kept the subject in a high degree of uncertainty about the nature and duration of the experiment and seem to feel that this uncertainty produced effects similar to those obtained in experiments of much longer duration This may be true in result if not in cause But for the researcher interested in predicting effects more clearly attributable to deprivation it might be well to distinguish such factors as realistically based concerns fear of the unknown attempts to obey instructions not to sleep etc along with cumulative exposure to the restricted sensory environment Many investigators seem to be striving to minimize apprehensions (e g Leiderman 1962 Zuckerman et al 1966 Smith & Myers 1966) One of the later Duke studies in fact showed that subjects given further information (e g nothing at all will happen to you) tended ($p < 12$) to show fewer nonspecific GSR fluctuations than did subjects in the high degree of uncertainty instruction detailed above (Culver Cohen Silverman & Shmavonian 1964) Interestingly enough from inspection of the figures in this report there seemed to be little or no perceptual mode differences in either instruction group and there was no mention of preexperimental shock tolerance determinations

Information of various sorts can realistically serve to frighten subjects A number of deprivation studies in recent years have appraised the possible influence of suggestive instructions and nonverbal cues in elicit

ing deprivation like phenomena (e g Kandel, Myers & Murphy, 1958, Jackson & Kelly 1962, Reed, 1962, Rossi, Sturrock, & Solomon, 1963, Murphy, Myers & Smith, 1963, Myers Murphy, & Terry, 1962, Orne & Scheibe, 1964, Zuckerman & Cohen, 1964b, see also chapter 3 of this book) It is now widely accepted that such influences can occur, but it does not follow that their magnitude is such as to "account for" deprivation phenomena Perhaps just as important is a growing literature whose message is that when instructing subjects "no news is bad news in the sense of "inflating indices of stressful deprivation symptomatology (Culver, Cohen, Silverman, & Shmavonian, 1964, Leon & Arnhoff, 1965) Evident in many recent studies is the giving to the subject of some plausible, low key rationale (e g, this is a study of relaxation) This middle road tactic is to give some structure to the subject in a matter of fact and open manner rather than (1) suggesting impending doom or (2) nurturing apprehension by ominous silence Sleep restriction is also tricky A study by Davis (1959) found a physiologic patterning' characteristic of 'anticipation among college students placed for 50 minutes in SD as compared to those in light and sound This may be an apprehension effect or as suggested by Stern (1964) the "instructions given to the subjects requiring them to stay awake may have constituted a relatively difficult task for those receiving reduced stimulation Difficult as it obviously is to control, minimize, or partial out these extraneous sources of reaction to deprivation, the need to do so should be kept in mind when reviewing (or planning) isolation studies For example many short term studies prohibit sleeping and provide jarring wake up reminders to the sleeping subject Possibly a great deal of the stress effects of short term isolation may be due to such aspects as apprehension and fighting to stay awake Moreover, it seems likely that personality would also interact with these factors

Perceptual mode has been used as a personological variable in several other short term studies In a carefully reported pilot experiment upon imagery over repeated exposures to brief periods of PD, Leiderman (1962) has described a number of interesting interrelationships Field dependent subjects evidenced greater total movement in the situation a lesser amount of imagery, and greater effectiveness of Defense against Primary Process on the Rorschach Since in various studies, restless movement during deprivation was symptomatic of disturbance (and predictive of eventual nonendurance) this would affirm the direction of greater maladaptiveness for the field type subject Despite the very small N, it is intriguing that the bodily oriented subject seems also to have been the more effective manager of primary process in the Holt and Havel (1960) sense

The results of Zuckerman et al (1966) are directly contrary to one portion of the Duke findings Although the significant correlations of

Embedded Figures Test scores with the various criteria of reaction to an 8 hour SD (and isolated but stimulated control) treatment were few body oriented subjects manifested fewer GSR fluctuations and less impulse reaction

Thus several studies of the role of perceptual mode in reactions to short term deprivation are unclear in composite Although undoubtedly a concept associated with many characteristic modes of responding it is at least questionable whether present evidence about varying reactions during deprivation is a function of the impoverished environment as distinguished from for example preservation of apprehension Even at that the present findings are inconsistent but perhaps favor the candidacy of the bodily oriented subject as potentially more tolerant of deprivation It will be interesting to see findings from prolonged duration studies in which such initial apprehension effects would probably dissipate

Sensation Seeking and Activity Needs

There is evident among less tolerant deprivation researchers a grass roots movement away from many of the established personality measures and concepts Certainly negative reinforcement has supplied motive power as indicated in the literature discussed so far But there are positive roots as well in the profound influence that optimal stimulation concepts have exerted upon psychological thinking of the past decade (Hebb 1955 Leuba 1955 Malmo 1959 Berlyne 1960 Fiske & Maddi 1961b) The pioneering perceptual isolation experiments at McGill of course had a primary role in stimulating the homeostatic theory that intermediate levels of stimulation are most supportive of organized behavior and are sought by the organism (Hebb 1955) It is then but a small step to seek individual difference measures of need for (or preferred levels of) environmental stimulation Much attention of late has been given to developing and validating sundry measures of change seeking sensation seeking and various activity needs One branch of this endeavour is the work of Maddi (1961) and Maddi Propst and Feldinger (1965) on TAT measures of the need for variety which has provided techniques yet to be used in deprivation experiments Another measure of the need for variable stimulus input is the Change Seeker Index (CSI) (Garlington & Shimota 1964)

Zuckerman Kolin Price and Zoob (1964) have reported development of a Sensation Seeking Scale (SSS) designed to quantify the construct optimal stimulation level Their technique was to select forced choice items on the basis of item difficulty and factor loading from an initial item pool pertaining to preference for extremes of sensation for the new and unfamiliar for irregularity for enjoyment of danger and thrills and so on SSS scores were significantly correlated with field independence (Embedded Figures Test) from which it was concluded that SSS tendency

is not a measure of impulsivity, but a measure of sensitivity to internal sensations SSS scores among females were associated with volunteering for an SD experiment, although the same was not the case in a male sample (Zuckerman Schultz, & Hopkins, 1967)

The Sensation Seeking Scale has been used in several studies of deprivation and immobilization Although SSS scores were not correlated with interview and ISQ measures of symptomatology or indices of affect change in 8 hour SD and social isolation groups (Zuckerman et al, 1966), significant associations were found with movement in both groups (and with heart rate variability in social isolation) In a subsequent 8-hour ex periment by Zuckerman, Persky, Link, and Basu (1968a), SSS scores were related to affect changes Unreality Stress and 17 ketosteroid measures in the condition of confinement with another subject, but little association was found with the same criteria within SD and social isolation condi tions Amount of listening to a boring stock market report, as a measure of stimulation seeking after 8 hours of SD was not related to subject s SSS scores (Smith & Myers 1966) A more encouraging result, perhaps affirming its relevance to movement was a finding by Zubek (1966, personal communication) that the mean SSS score of 16 subjects enduring 7 days of immobilization (but undeprived in other respects) was significantly ($p < 05$) lower than that of 9 quitters' Yet, no relationship was found by Zubek (1966, personal communication) between SSS and endurance of 4 day PD Thus, a soundly constructed instrument to appraise sensation seeking propensities has had a spotty record to date as a predictor of deprivation tolerance

The approach of this reviewer and his colleagues Smith, Murphy, Johnson and others at HumRRO and NMRI has been to seek measures of life style of seeming proximity to the deprivation situation itself Rather than consider how extremes scorers on a personality dimension might fare in isolation, we have looked to the deprivation situation for clues as to important needs or habits denied by it An obvious aspect of SD is the cluster of features—e g darkness, silence, confinement, inactiv ity, solitude, etc —which subjects may simply dislike normally in varying degree Scoring such dislikes provided the measure Dark Quiet Cell (DQC) Phobia mentioned earlier Another obvious feature of SD (like falling asleep) is the opportunity to brood This led to the scale Chronic Worry Still another limitation imposed by SD is the lack of companion ship hence some items were keyed as a Sociability scale Due to the rela tive lack of physical activity in the SD cubicle, a grouping of items dealt with desire to be moving about and doing things It seemed that this Activity need might be quite different from desire for a rich diet of thrills or kicks which monotonous SD certainly lacks So a Thrill-Seeking scale was devised Among the five HumRRO activity' measures ob tained Worry and Phobia measures were moderately correlated and Ac

tivity need was slightly but significantly correlated with Thrill Seeking and Sociability

Since the five life style measures were derived from an item pool given in the 6-day SD experiments at HumRRO it was possible to examine each scale with respect to (1) volunteering for the SD experiment and (2) the ability to endure 6 day SD Three of the measures were significantly related to volunteering Volunteers were lower on DQC Phobia and Activity need but higher on Thrill Seeking (Myers Smith & Murphy 1967) This thrill seeker-as-volunteer fits with some of the literature on the volunteer (e g Schubert 1964) and with the SSS findings for females Note also that Activity and Thrill-Seeking scores behaved in opposing directions confirming the separation of the two (High Thrill Seekers sought but high Activity subjects avoided participation) Among the somewhat screened volunteer group 94 subjects entered SD of whom 33 completed the 6-day isolation Two of the life style measures showed significant (one tailed) relationships with endurance Early release subjects had higher scores than 6-day subjects on DQC Phobia and on Thrill Seeking In effect then high Phobic scores successively characterized the nonvolunteer and then the nonendurer suggesting a more powerful relation to SD tolerance in a (hypothetical) population not limited to volunteers On the other hand Thrill Seekers more frequently opted for the experiment but exhibited less staying power once in the SD environment The latter effect has a flavor similar to the HumRRO 4 day SD findings of higher Pd and Ma MMPI scale scores for the early release subject (Table 9–2) and the preliminary NMRI result of higher Ma scores for the non enduring subject in 7-day SD A lucid discussion by Quay (1965) of the psychopathic personality as pathological stimulation seeking' also seems most relevant

Research on activity need measures has continued at NMRI To understand better how the five measures and other measures of sensation and activity needs might interrelate a factor analysis has been run on a set of 28 scores from 95 Navy enlisted men subjects These unpublished findings now being replicated produced five orthogonal factors tentatively labeled Sociability Cognitive Complexity Thrill Seeking Worry and Vigor Factor analysis output is of course conditioned by its input But most interesting was the separation of Thrill and Vigor The latter factor was anchored by liking of contact sports and Activity need (HumRRO) and thus seems to have a healthy energy cast The Thrill factor showed high loadings for the CSI Thrill Seeking (HumRRO) Kipnis Insolence scale Zuckerman SSS Lykken (sociopathy) scale and the Ma and IR scales of the MMPI The sociopathic flavor of this grouping is obvious Factors Sociability Worry and Cognitive Complexity were straightforward although the latter has received little attention in deprivation research other than some measures of intelligence and the work

of Suedfeld (1964a) on integrative complexity, indicating among other things that more integratively complex individuals rate 24-hour SD as more "stressful." Incidentally, Zuckerman's SSS, true to its origins in a diversity of items, had appreciable loadings on Thrill, Vigor, and Cognitive-Complexity factors. This affirms its claim as a general index, although the significant correlations between SSS and the enumerated elements of the Thrill factor suggests that it may measure aspects of impulsivity after all. The HumRRO activity scales loaded heavily in the obviously appropriate places. The working hypothesis of the NMRI researchers is that it may be useful in predicting tolerance to distinguish and measure various facets of an individual's preferred life style which result in differentiated input. Broadly interpreting the findings just described, persons may receive more varied input as a function of (1) how complexly they perceive a given environment; (2) how extensively they engage in interaction with others; (3) how vigorously and energetically they behave; (4) how actively they pursue thrilling or dangerous experiences; and, much less clearly, (5) how prominent a role is played by anxious ruminations. In any event, a profile of measures developed along these lines has played a prominent part in our attempts at NMRI to predict tolerance of short-term and prolonged deprivation durations.

In summary, a number of new measures of stimulation seeking and activity needs have been developed, which seem particularly pertinent to deprivation tolerance. A Sensation-Seeking Scale (SSS) has correlated with some measures of behavior in short-term confinement, but most notably with failure to endure prolonged immobilization. Of a loosely related group of five "activity" measures, Thrill Seeking was associated with willingness to volunteer for but inability to endure 6-day SD. In addition, "phobic" dislike of confinement conditions was associated with reluctance both to volunteer for and to remain in prolonged SD. Measures of these types, rather closely linked to the deprivation concept itself, appear to have promise for tolerance prediction.

Early-in-Isolation Predictors

If measuring sensation seeking and activity needs represents a step toward greater conceptual approximation of the deprivation situation, one can go even further in this direction by seeking estimates of early response while in the deprivation situation itself. Strictly speaking, early-in-isolation reactions are not true predictors in that they do require immersion of the subject in the restricted environment. However, any promising findings from such studies could well guide the creation of a brief isolation situation (even a "waiting room" setting) as a context for measuring potential tolerance for extended deprivation. Because many of the early behavior studies have employed the criterion of endurance, much of the material was briefly touched upon in the preceding section on tolerance criteria.

A brief article from the Princeton laboratory (Vernon & McGill 1960) reported a clear cut association ($p < 01$) between time spent using a viewing box and eventual success in enduring 3-day SD Nine subjects destined to complete this period of SD clocked a mean of just 13 seconds viewing a dimly lit geometric pattern within the first 24 hours of SD as compared to an average of 183 seconds for six subjects who subsequently requested early release Other data demonstrating the negative association between staying power and early stimulation seeking in the auditory modality has come from an NMRI experiment (Smith Myers & Johnson 1967) In this study boring stock market reports were available to subjects for 1 hour periods on each of days 1 4 and 7 of an SD condition SD subjects selected to listen significantly more than live in the laboratory control subjects with the magnitude of the difference increasing with time Day 1 listening times (about 6 hours after isolation began) were significantly associated by χ^2 test ($p < 05$) with endurance times in SD Nine of 11 subjects remaining less than 4 days in SD scored above the median on day 1 listening 4 of 8 subjects remaining 4 but not 7 days scored high while only 7 of 21 subjects remaining 7 days had high listening scores Thus the two studies showed that the extent of utilizing visual and auditory stimulational sources early in isolation was inversely predictive of endurance in multiday SD

Another state measure of behavior in deprivation is gross motor restlessness In one HumRRO study (Smith Murphy & Myers 1962) of 4 day SD restlessness indices during the daytime period of day 2 were strongly associated with likelihood of enduring 4 days Upon median splitting restlessness rate measures it was observed that 15 of the 18 early release subjects but only 5 of 23 maximum enduring SD subjects showed high degrees of restlessness ($p < 001$) Further evidence of the inverse bearing of restlessness upon endurance was the correlation of -62 ($p < 02$) between the two measures within the group of 18 early release subjects Interestingly enough there was no relation of day 1 restlessness to endurance which the authors attributed to the rather widespread sleeping on the part of SD subjects during the initial period of isolation

In another HumRRO experiment (Murphy Hampton & Myers, 1962) estimated time passage was inversely linked to endurance of SD Subjects estimating a greater elapse of time after just 4 hours in SD (thus those for whom time seemed to drag) were more likely ($p < 025$) to be unsuccessful in completing 4 days of SD The 25 early release subjects overestimated the 4 hour interval by 3 7 hours whereas the 23 long staying subjects overestimated an average of 1 1 hours Moreover in a finding parallel to that for restlessness degree of overestimation within the early release group correlated significantly ($r = -43$ $p < 05$) with number of hours endured

Several more recent studies have shown subjects daily reports of affective state to be predictive of whether or not the subject will endure

the prescribed period of deprivation. Higher Subjective-Stress Scale (SSS) ratings (Kerle & Bialek, 1958) were made by subjects on days preceding their early release than by subjects who eventually endured multiday isolation. Such was the outcome in a 7-day PD experiment (Zubek & Schutte, 1966), in a 7-day immobilization study (Zubek, 1968a), and in the just completed 7-day SD study at NMRI. Thus, elevated "stress" feelings rather early in deprived confinement seem symptomatic of low endurance capacity.

In summary, a series of multiday deprivation experiments have implicated several behavioral states early in isolation as indicative of eventual nonendurance. Greater stimulation seeking propensity (visual or auditory), elevated day 2 restlessness, greater overestimation of time passage, and higher subjective stress ratings all proved to be measures which quite accurately forecast early departure. The strength and cogency of these findings rank very high in the literature on deprivation tolerance, although unfortunately they are of little practical value in any true prediction effort.

Other Variables Affecting Tolerance

This final section will consider anticipatory states, during-deprivation activities, repeated exposure, and baseline physiological states in relation to isolation tolerance. With the exception of the latter, these important topics deal with experimentally or procedurally induced states of potential relevance to an individual's deprivation tolerance, rather than with personological state measures as discussed in the preceding sections.

Anticipatory states. Evidence of somewhat "stressful" apprehension of deprivation situations has been obtained in several studies. In each of two HumRRO studies (Myers, 1964b), Subjective-Stress Scale (SSS) ratings from subjects soon to begin 4-day SD were significantly higher ($p < .10$; $p < .05$) than those of subjects just assigned to the normal activity control condition. The magnitude of this apprehension effect, however, only tended to predict eventual early release ($p < .10$; $p < .20$). Nor was subjective stress at the time of the volunteering decision related to later endurance scores in SD. Zubek and Schutte (1966) have also obtained evidence of SSS apprehension of PD, the degree of which was not related to completion of 7-day PD. Thus, although the subjects in these experiments registered clear-cut elevations in subjective stress with the approach of isolation, these anticipatory reactions did not reliably signal their endurance potential.

Suggestibility as a subject trait was studied by Camberari (1959) in relation to tolerance for water-immersion SD. Volunteer graduate students, later grouped on the basis of their composite suggestibility scores, were required to read reports of sensory isolation experiments before

immersion in a Lilly type tank for an indefinite period Most clear-cut was the result that the more suggestible subjects remained significantly longer in the tank ($p < .01$) It was also tentatively concluded that the suggestible subjects produced more regressive phenomena and were more tolerant of them than were nonsuggestible subjects The latter subjects tended to be more threatened by disturbances in body schema and more concerned about intellectual control Thus the subjects most responsive to various tests of suggestibility appeared to have responded quite differently to SD (and in ways reminiscent of primary process tolerators of Goldberger and Holt) It is not entirely clear whether the SD reactions of suggestible subjects conformed more closely to expectancies induced by the pre-SD information or whether suggestibility as a personality measure may have more independently influenced response to isolation

Suggestion as experimentally manipulated expectancy is a topic too extensive for review in this context There is little doubt that implicit and instructional sets on the part of the subject can influence his readiness to report various deprivation like phenomena particularly during the brief experimental periods usually studied Unfortunately there is little data to indicate how various sets might influence basic deprivation results nor how set might interactively modulate the results of tolerance prediction studies That is it is conceivable that a given personality trait—e g manifest anxiety level—may relate more strongly to tolerance under one instructional set—e g one provoking anxiety—than under another instructional set

The role of expected duration of deprivation has been a rather neglected research area An interesting experiment by Francis (1961) examined endurance in a water immersion situation as a function of the factorial combination of duration and time knowledge Subjects were instructed to stay 3 hours or to stay as long as possible in combination with either being told nothing during immersion or being told the time every 20 minutes The interaction of instructional conditions was significant ($p < .01$) Subjects in the 3 hour group given 20 minute time signals almost invariably remained for the 3 hour actual duration whereas those attempting to stay as long as possible in the presence of these same signals lasted an average of only an hour and a half When no time cues were given the duration goal groups were more similar and in the reversed direction Thus, time interval markers facilitated attainment of a definite duration goal (by assisting in self pacing ?) but impeded staying as long as possible (perhaps by documenting the slow passage of time?) Equal numbers of male and female subjects were employed in the groups and sex of subject produced no significant general or interactive effects

During isolation activity In addition to the various studies varying method and degree of sensory restriction *per se* several studies have ascertained the effects of movement exercise and extent of behavioral testing

during the confinement period. Although in one sense methodological, they also bear upon potential means of increasing deprivation tolerance. In a 4-hour PD study in Boston, 9 subjects performing a large body movement on cue every few minutes were compared with another 9 subjects who merely moved their index finger on the same schedule (Courtney, Davis, & Solomon, 1961). Grossness of movement was unrelated to imagery, emotional responses to PD, and posttreatment cognitive performance, although the finger movement group experienced more frequent visual distortions. The study contained no nonmovement condition (and no non-deprived baseline), so it was not possible to evaluate whether or not *both* movement conditions were deviant from nonmovement during PD or even whether true PD effects occurred. The Manitoba laboratory has provided convincing evidence that physical exercise mitigates many of the effects of 7-day PD (Zubek, 1963a). Subjects required to perform various physical exercises for about 30 minutes during each of 7 days in PD exhibited fewer impairments on 15 behavioral measures and a significantly smaller mean decrease in occipital lobe EEG frequency than was obtained for subjects in an otherwise identical "no-exercise" PD group. However, the proportion of subjects enduring 7 days in the two groups was quite similar, as was the low percentage of subjects reporting visual hallucinations. Thus, programmed movement during PD was an effective determiner of the magnitude of important PD effects, but not of endurance potential. In still another experiment by Zubek (1964b), the 7-day PD condition was made more severe by use of heavy gloves and the elimination of all testing intrusions. Similar to the results observed under a less severe deprivation condition (Zubek et al., 1962), size constancy and incidence of visual hallucinations was not affected, and the percentage of 7-day completers (75 percent) did not change appreciably from the earlier (69 percent) value.

In a brief summary of several experiments in a water-immersion experiment of indefinite duration, Schaefer (1964) has compared reactions of five untrained subjects with those of six subjects given 4 weeks of training in geometrical construction and projective geometry. The trained group surpassed the untrained group in endurance time and showed relatively less excretion of adrenaline and noradrenaline, and lower rates of pulse and respiration.

In summary, there is solid evidence that exercise during PD mitigates EEG and behavioral effects but does not affect endurance. Interspersed testing does not seem to markedly affect PD tolerance, and training in geometrical construction appears to increase endurance and to diminish endocrine response during water-immersion.

Repeated exposure. Of considerable importance is the question of whether or not repeated exposures to deprivation leads to tolerance changes. Two studies of repeated exposure to short-term isolation found little change in likelihood of enduring either two 8-hour PD sessions or

two 3 hour sessions (Pollard Uhr & Jackson 1963a) There were however significant reductions over sessions in each study in the number of words spoken and in many self report effects The consensus from longer term and more severe deprivation studies support the notion that subjects may adapt favorably to the reduced sensory environment over successive exposures For example Zubek et al (1962) state that three of four subjects found 7 day PD much easier to endure than a previous 7 day period of SD Similarly Ruff Levy and Thaler (1961) reported that most of their subjects participating in several deprivation experiments found each easier than the previous one Finally Suedfeld Vernon Stubbs and Karlins (1965) reported an impaired performance on an unstructured cognitive task after one day of SD This effect however disappeared when the same subjects underwent a second 1 day session a week later Most of the evidence is suggestive however and firm data on tolerance shifts and their possible interaction with personal trait factors would be of great value in a realistic estimation of extended monotony tolerance as well as to our conception of deprivation phenomena

Baseline physiological states Little information has been obtained in past research on the possible bearing of baseline measures of psychophysiological states upon isolation tolerance The expense and difficulty of obtaining data sufficient to the correlation task may be responsible for this gap Two recent studies from the Manitoba laboratory have yielded promising data on the relevance of baseline levels of catecholamines In the first experiment (Zubek & Schutte 1966) the preisolation adrenaline level of 13 eventual quitters was significantly lower ($p < .01$) than that of 18 successful 7 day PD subjects Because the same effect was observed 2 days and 6 months postisolation this adrenaline baseline difference suggests that the isolation intolerant individual may be biochemically or constitutionally different from volunteers who can endure a prescribed period of prolonged isolation No such finding was observed for noradrenaline secretion

The second experiment (Zubek 1968a) examined catecholamine and subjective stress reactions of 26 subjects undergoing 7 days of immobilization without other sensory restrictions A lower adrenaline baseline prior to the experiment was again observed in the ten immobilization quitters but the results only bordered on statistical significance These biochemical differences in quitters and stayers in sensory restriction settings suggest that the subjects may also differ in personality There was however no obvious parallel difference in scores from the Rorschach MMPI TTS and PPS in that no single personality score significantly differentiated the PD endurance subgroups (Zubek & Schutte 1966) This does not preclude the possibility that biochemical state measures may usefully relate to other personality scores or patterns and aid in the process of defining personological types ill suited for monotonous isolation These

initial studies certainly affirm the promise of considering biochemical state measures in future deprivation studies For example metabolic efficiency indices of sheer energy combined with activity need (and perhaps defense style) measures may pinpoint those individuals seemingly incapable of monotonous inactivity

EVALUATIVE SUMMARY

The research literature on personal factors associated with deprivation tolerance is diverse and outcomes on the whole, are disappointingly inconsistent. This is not altogether surprising in view of the wide procedural variations probable multiplicity of relevant predictors diversity of criteria employed, and the interactions of these considerations

Procedural differences over studies are commonly cited as culprits whenever the results vary, but the ranges of these differences are nonetheless truly impressive

1 Many techniques have been used to limit sensory experience (bed confinement, water tanks respirator confinement etc.)
2. Duration of deprivation has varied from a few minutes to many days and there is evidence that duration strongly affects tolerance measures
3 Subject sets induced by instructions and nonverbal cues have probably varied considerably although by definition they are essentially undescribable by one researcher to another- sets may well have potentiating effects upon predictive factors
4 Subject samples have often been quite small relative to the seeming variability of measures-to-be predicted perhaps dooming to rejection many plausible hypotheses.
5 Motivations of subjects have varied over studies (e g self testing money etc.) with unknown consequences for tolerance prediction
6 Subject samples have probably been relatively homogeneous on many personality factors, demonstrably so in instances when participation has been limited to volunteers

Many personality factors are probably related to deprivation tolerance Certainly it is evident by now that no one single predictor variable consistently accounts for the major portion of the individual differences in response to isolation The sensory reduction situation is seemingly such that many sources of the variation in how a subject can tolerate himself in a drastically impoverished environment are probably carried into the situation by the person himself A multiple predictor model implies several things

1 Single factor hypothesis studies must judge criterion variance contribution against a residual variance containing both error and untapped true variance hence it would be difficult to attain an impressive significance level

2 The odds of attaining replicated outcomes each at conventional levels of sig nificance already an extremely conservative procedure in one view becomes even smaller

3 The failure of most studies to report even the direction of differences much less trends makes it impossible to seek low magnitude consistencies

The *tolerance criterion question* looms large in a research area mak ing progress by lifting one s self by the bootstraps Endurance time is a simple face valid tolerance measure used in most long term studies How ever, it cannot be used in short term situations where few subjects request early release and it is wasteful of information in cases resulting in a dichotomy Short term studies must use other criteria e g visual imagery sundry discomfort indices affect scales etc which may or may not be re lated to endurance yardsticks in prolonged isolation Thus the various tolerance criteria used in the literature may well be unrelated with the obvious implication that their true *predictors* may be *completely differ ent* Even assuming that tolerance can be similarly measured in all studies there are still two basic questions involved in attribution of predictive relationships to deprivation (1) If under the conditions of a given experi ment tolerance scores are not experimentally affected by impoverishment then by definition the SD environment is no more relevant to the phe nomenon measured than is the non SD environment (2) Moreover if the correlation of a predictor with the criterion within the SD condition and within the non SD condition are similar then it is also questionable whether SD has any more bearing upon the association than does the non-SD setting Virtually the entire tolerance prediction literature fails to meet these SD salience standards Future knowledge may reveal that much of our present information is totally irrelevant to SD in the two senses outlined Even to evaluate this SD salience in these respects re quires that a tolerance criterion be applicable (1) to deprivation conditions of any duration (which endurance is not) and (2) to nondeprivation base line conditions Meeting these requirements are several recently devel oped techniques such as the Isolation Symptomatology Questionnaire and several affect appraisal techniques which have also shown great prom ise as endurance-correlated barometers of deprivation reaction Note worthy too are recent findings that several distinctly different symptom patterns are each associated with poor endurance If we accept the view that a number of personality types may find deprivation particularly difficult it seems only reasonable to expect that each type may express his discomfort in a characteristic fashion clearer prediction outcomes may *require* examination of these more specific linkages

Evaluation of the most *promising personological correlates* of dep rivation tolerance is a highly personal process Confessing at the outset his bias in favor of prolonged (or severe) experiments with sizable Ns and endurance as the tolerance criterion the author of this chapter would

highlight the following factors as most promising: (1) *Effectiveness of coping with primary process material* was impressively related in the positive direction to endurance of prolonged 7-day PD (Wright & Abbey, 1965). The measurement technique stemmed from the conceptions of Holt (1956) and its experimental validation was partially successful for 8-hour PD in the studies of Goldberger and Holt. The concept employed seems very directly relevant to altered consciousness states and emergence of basic-drive-dominated experience in an environment ill-supportive of the more "rational" thought processes. (2) Relatively *rapid perceptual satiation* was inversely associated with endurance in PD (Petrie, Collins, & Solomon, 1958). (3) *Lower baseline excretion of adrenaline* was associated with failure to endure 7-day PD in one study (Zubek & Schutte, 1966) and also tended to characterize subjects intolerant of immobilization (Zubek, 1968a). (4) *Relatively high Pd and Ma* scores on the MMPI, *high thrill-seeking* scores, and high EPPS *need Aggression* scores have rather consistently characterized the early release subject in various studies of multiday deprivation at the HumRRO, Manitoba, and NMRI laboratories. Each of these measures has shown consistency rather than strength of relationship. Considered jointly, the findings suggest that the psychopathic personality, needful of impulse expression, "kicks," and room to manipulate others, is poorly suited for the task of enduring inactive, nonstimulating solitude. Certain biographical characteristics of the isolation-quitters in Manitoba and/or HumRRO studies may be associated with this cluster. Younger subjects, more prone to TV-watching and smoking, but not reading, tended to seek early release. Rapid perceptual satiation and characteristically low adrenaline levels (requiring "pathological stimulation seeking" as a means of maintaining arousal?) already mentioned, may well be related to this cluster also.

A number of other areas of the literature seem to have yielded, on the whole, inconsistent findings. Sex of the subject, introversion-extraversion, and various measures of neuroticism and anxiety have been examined in a number of experiments without clear consensus of outcome. Field dependence was related to reactions to brief deprivation periods but has yet to be tried in more extreme situations. Similarly, the new measures of sensation seeking and activity needs appear to hold promise for future studies but have not been extensively evaluated.

As yet untried techniques may have merit. Systematic data on subjects' motivations to become involved in deprivation experiments, and the goals they expect to attain thereby, may well provide valuable means of forecasting tolerance. In many situations, too, important information about a person can best be sought from his peers. Groups of subjects given a chance to know one another may well be better able to assess traits pertinent to isolation tolerance than are some of our standard testing instruments. Normal baseline measures of biochemical states, other than

catecholamines—e g metabolic indices—may also prove of value in future research

The potential value of *multivariate analysis techniques* in the study of deprivation tolerance deserves special emphasis Multiple discriminant function combinations of standard MMPI EPPS and TTS measures in the Manitoba studies yielded significant prediction of PD endurance in one study and in a replication (Wright & Zubek 1966) Robust prediction of tolerance to a degree having any real practical significance seems almost certain to be attainable if at all through some multiple factor technique It would be particularly interesting to see how a combination of the more individually promising measures might fare in future studies

In any case the way to deal with complex problems is to respond complexly and analytically Perhaps no great improvements are in store for us in the endeavor to predict SD and PD tolerance But in the words of the contemporary social philosopher The future lies ahead

10

Clinical Sensory Deprivation: A Review of Hospitalized Eye-Surgery Patients

C. Wesley Jackson, Jr.

Although sensory reduction and other changes in stimulation accompany many medical disorders and treatment procedures "clinical sensory deprivation" is not clearly defined Thus although some clinical studies have been explicitly identified with sensory deprivation, the relevance of others depends upon the judgment of the reader Studies of "clinical sensory deprivation" and other studies which might be so identified have included subjects in four quite different settings

First, there are the following patients who are hospitalized people with eye disorders, orthopedic patients and others whose movements may be severely restricted by bedrest, casts, or traction, patients with communicable diseases who are socially isolated for the protection of others, patients whose susceptibility to infection requires "reverse isolation" for protection from others, laryngectomy patients and those placed on voice rest, patients with neurological disorders, and those who are confined for long term rehabilitation Reports for some of the above patients have indicated sensory, cognitive emotional and behavioral experiences (i e, "symptoms") which appeared similar to those reported for normal subjects during laboratory studies of sensory deprivation (Jackson & Pollard, 1962 Jackson, Pollard, & Kansky, 1962, Leiderman, Mendelson, Wexler, & Solomon, 1958) In addition similar appearing experiences also have been reported for other medical and surgical patients especially those hospitalized for heart surgery (Kornfeld, Zimberg, & Malm, 1965)

Second, reduced sensory functioning is of course a major concern for many nonhospitalized people as well Studies of the blind and of the deaf have been focused more upon the many practical problems associated with sensory deficiency than upon the specific effects of sensory deprivation

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per se (Ashcroft & Harley 1966 Rosenstein 1966) People who have restrictions upon their movements or who are confined to bed those who are unable to speak and those who have had amputations also experience significant sensory alteration In addition some people suffer loss of taste or smell as a function of the radiation treatment given for certain cancer conditions

Third studies of clinical sensory deprivation have included those in which social and sensory deprivation have been used to treat psychiatric patients (Azima Vispo & Cramer Azima 1961 Cohen 1963 Gibby Adams & Carrera 1960) Fourth there have been studies in which subjects with medical or psychiatric problems have been used in laboratory investigations similar to those employing normal people as subjects (Mendelson Siger & Solomon 1960 Reitman & Cleveland 1964)

The examples given above illustrate the extensiveness and heterogeneity of clinical sensory deprivation It also is apparent that the phrase clinical sensory deprivation alone does not adequately communicate the sensory conditions for any specific group of people Furthermore the distinction used in this book between sensory deprivation and perceptual deprivation is not sufficient A single patient may concurrently experience several alterations in stimulation including reduced amount or intensity of some stimuli reduced patterning of stimuli increased intensity of other stimuli the addition of very new stimuli changes in the meaning of stimuli and perhaps other alterations as well These various alterations may differ for people within a single group and certainly will change for different groups of people and different situations Therefore one cannot meaningfully discuss clinical sensory deprivation in general terms but rather one must examine the sensory conditions for a particular group of people in a specific situation

Moreover one must consider other important clinical variables which vary depending upon the medical disorder and the particular setting For example are the effects of sensory reduction the same if the deprivation results from pathology of the sensory organs *per se* from a more general bodily disorder from nonphysical factors such as eye patches and body casts or from a combination of all three? What is the influence upon the effects of sensory deprivation if the condition is acute or chronic temporary or permanent? Do the self reported effects vary depending upon whether the subjects feel that they are perceived as patients, as cripples as burdens or as productive members of society? What further clinical variables are present which might significantly influence the behaviors under study? Drugs toxic processes anxiety and surgical trauma are just a few of the many possibilities

Although clinical sensory deprivation covers a lot of ground and offers many possibilities for worthwhile investigation the unique characteristics of different groups and settings far outnumber their similarities

Within a single chapter, a reviewer has the alternatives of either superficially covering many diverse reports or more intensively reviewing one particular area An additional complication is that the methodological inadequacies of many clinical reports are such that it often would be grossly misleading to merely give a brief description of the reported findings

The purpose of the present chapter is to provide an intensive review of one group of sensory deprived people, patients who are hospitalized for eye surgery These patients are the ones most frequently identified with clinical sensory deprivation, and they have been studied over a period of many years It should be emphasized again that although the problems, procedures findings, and conclusions reviewed for reports of eye surgery patients will also have some relevance for other groups of sensory deprived patients an adequate understanding of those patients will require intensive review of each different group

HOSPITALIZATION FOR EYE SURGEPY

Patients with a number of different eye disorders have been included in some reports but by far the most common are those with cataracts A smaller but still important subgroup in recent years are those with a detached retina A brief description of these two conditions and their treatment will be given For additional reference Vaughan, Cook, and Asbury (1965) provide a comprehensive, technical description of eye disorders and their treatment, Miller (1964) a study and discussion of people with cataracts, and White and Levatin (1962) some interesting aspects of surgery for detached retina

Cataract Extraction

A cataract is a development in the lens of the eye, which changes the lens from its normal transparency to an increasing opaqueness thus decreasing vision and in some cases eventually causing blindness Although there are different types of cataracts the most frequently cited are senile cataracts, those associated with aging Senile cataracts occur in men and women and frequently in both eyes The condition becomes progressively worse with age and in a given individual each eye often progresses at a different rate Vaughan, Cook, and Asbury (1965) indicated that almost everyone over age 60 has some degree of cataract, although obviously only a small proportion progress to the point of requiring surgery Investigators may expect that the average age of adult subjects who undergo surgery will be at least 60 (Ziskind, Jones Filante & Goldberg 1960, Jackson & O Neil, 1966)

Surgery for cataract is elective and involves extraction of the lens from the eye Surgical and associated treatment procedures have changed considerably over the years some of these changes may be related to differences between investigators reports (Ziskind 1958) Even present-day researchers may expect to find that surgeons differ about preferred treatment and that a given surgeon will adapt his procedures for different patients

Given the above variations a typical sequence for a private patient might be as follows He develops progressively poorer vision in one or both eyes over a number of years and he has a succession of clinical contacts as an outpatient The decision to operate is made at a time when vision in the to be operated eye is very poor or nonexistent and depending upon the physician when vision in the other eye is relatively poor as well There is usually a waiting period until a hospital bed is available following which the patient is admitted and operated upon the next day Surgery is usually conducted without general anesthesia During the preoperative period the patient will receive varying amounts and types of explanatory information depending upon the physician the patient's friends and relatives the hospital staff and others

Following surgery the patient will lie on his back in bed and will be instructed not to move or to move as little as possible for about 8 hours Subsequently he will be allowed to lie either on his back or on his unoperated side but not on his operated side On the first or second postoperative day he will be permitted to sit up and then to get out of bed for increasing periods of time The patient will receive medication which may include sleeping pills and tranquilizers The operated eye will usually be patched for the duration of hospitalization The unoperated eye may be patched for varying lengths of time or it may be left unpatched Hospitalization usually lasts from a week to 10 days Patients may have a private nurse or companion in attendance particularly for the first couple of days after surgery Vaughan Cook and Asbury (1965) state that when surgery is indicated for senile cataract improved vision results in over 90 percent of the cases It is not uncommon for a patient subsequently to have surgery on the other eye

Surgery for Detached Retina

The retina or light sensitive portion of the eye is normally attached to the choroid For any of a number of reasons a tear may develop in the retina permitting fluid to enter and separate the retina from the choroid This results in a sudden partial or total loss of vision in that eye Retinal detachments occur in men and women and according to Vaughan Cook and Asbury (1965) occur in both eyes at different times in approximately 25 percent of the cases The average age of patients with detached retinas is less than that for patients with cataracts In two studies the average ages

for retinal detachment patients were 39 and 55 years as compared to 60 and 66 years for cataract patients (Ziskind, Jones, Filante, & Goldberg, 1960, Jackson & O Neil, 1966)

Surgery for detached retina involves repairing the tear or tears in the retina, draining the fluid between the retina and the choroid, and reattaching the retina to the choroid It is estimated that surgery is successful in 70 to 75 percent of the cases Patients may require further surgery if the initial operation is not successful or if further detachments develop

Retinal detachment is considered an acute condition Hospitalization and surgery usually take place as soon as possible In the interval preceding surgery the patient usually is put to bed and wears patches or pinhole glasses over both eyes Similarly following surgery, both eyes are patched, and patches or pinhole glasses remain on throughout hospitalization Hospitalization typically is longer than that required for cataract surgery In addition, the detached retina patient's movements are more restricted Patients receive various medications and may or may not have a private duty nurse or someone else in constant attendance

Relevance to Sensory Deprivation

Although having surgery for a cataract or a detached retina is a complicated process involving many variables, the logical relevance to sensory deprivation is apparent Reduction in visual stimulation occurs because of the eye pathology *per se* and because of the eye coverings Because patients with cataracts are usually elderly, some of them have some loss of hearing This is less true for the younger patients with detached retinas Because of restrictions placed upon movement, there is a reduction in bodily (somesthetic and kinesthetic) stimulation Social isolation and reduced opportunities for talking may be significant deprivation variables depending upon the type of room (private, semiprivate, or ward) which the patient has the availability of hospital staff, the presence or absence of a private nurse, and the frequency of visits from friends and relatives Recumbent position and drugs may also decrease stimulation Finally, there is the transition to the hospital and an accompanying loss of familiar surroundings, usual activities and other customary forms of stimulation Thus the relevance of sensory deprivation to eye surgery patients is not solely due to the eye patches but rather to a complex group of sensory deprivation variables

portant to maintain a historical perspective in reviewing these reports as well as consolidating their various contents Thus we will first review the case reports by three content categories Patient Behaviors Explanatory Variables and Prevention and Treatment Case reports and reviews will be presented chronologically Following this we will review the four more recent investigations

CASE REPORTS AND REVIEWS

Patient Behaviors (symptoms, experiences effects etc)

In this section we will review the patient behaviors which have caused concern among clinicians and which have prompted interest in clinical sensory deprivation One immediate difficulty is that the terms or labels which are used to describe and categorize various behaviors are often ambiguous and unclear Some have gone out of fashion and others have changed in meaning Consequently the behaviors presented in each clinical report will be given using the original author s labels together with the date of the report In addition to the behaviors *per se,* this section will include the frequency and time of occurrence sex age and diagnosis of the patients and relevant sensory deprivation conditions

Colman (1891) reported three cases one man and two women aged 50 38 and 50 who were diagnosed as having syphilitic retinitis old choroiditis (and epilepsy) and retinal hemorrhage (together with pernicious anemia) Although two of these patients were in bed no further information was given about deprivation conditions These patients had visual illusions and hallucinations which included seeing beetles with red eyes on the bed a woman in red and on fire faces from the past and a blackbird perched on the bed Even though Colman distinguished between illusions and hallucinations (the woman on fire was a nurse dressed in an ordinary uniform) he believed that there was no essential difference

During a medical meeting at the turn of the century Posey (1900) reported about 24 cases of delirium Nineteen had cataract extractions three had iridectomy for glaucoma and the other two were treated for eye wounds The sex of the patients was not given but some information was given about their ages Two patients were in their fifties nine in their sixties six in their seventies and five in their eighties The remaining two patients were younger people who had received eye wounds All patients had both eyes patched following surgery The delirium began with mental restlessness and rapidly progressed to hallucinations and ideas of persecution Delirium developed during the first 24 hours after surgery in two patients during the second day for eight patients the third day for six and the fourth day for two The onset of delirium was not noted for the other six patients In the discussion following this report reference was

made to other eye patients who developed mental symptoms labeled maniacal delirium, dementia, and mental aberration

Kipp (1903) gave 12 case descriptions of patients on wards in eye hospitals They included nine men and three women, half of whom ranged from 35 to 50 years and half from 60 to 78 years Six had operations for cataract, three for wounds, and one for glaucoma Two were treated medically for ulcers of the cornea Some of these patients were confined to bed and others were not One patient had both eyes bandaged, one had neither eye bandaged and ten had one eye bandaged At least four of the latter group, however, had poor to no vision in the unbandaged eye Most of the patients were in lighted rooms and about three fourths were with other patients

The mental derangement described for these patients ranged from mild to severe symptoms with subsequent suicide The 12 cases included instances of restlessness, sleeplessness, screaming fears that the nurses would hurt them, hearing rats and mice, hearing the sounds of small pox patients being taken out of the hospital at night, seeing snakes, lizards or imaginary specks escaping from the hospital, attacking a nurse, smashing windows and jumping out of windows Most of the symptoms developed between two days and two weeks postsurgery or postadmission

Finlay (1904) presented a single case, a 66-year-old woman with cataracts on each eye Both eyes were patched following her first surgery, and she became violently delirious She got up several times tore her bandages off, and had to be restrained Her symptoms lasted several days and worsened at night During the same hospitalization she had surgery on her other eye There was some nervousness that evening, but none of the more extreme behavior which followed her first surgery Finley also gave an interesting statistic "Although I have had several cases of extreme nervousness and unruliness after eye operations, especially after cataract extractions, the preceding is the only one of out and-out delirium of the violent type not of alcoholic origin which I have had in 294 cataract extractions (p 7)

Parker (1913) reviewed 376 cataract extractions which were performed in the clinic of the University of Michigan from 1908 to 1912 Out of this study which included 233 men and 143 women, seven men and four women or 3 percent of the total population, were reported to have had delirium The average age of these 11 patients was 72 with a range from 53 to 82 years These patients were in bed and probably had both eyes patched Parker alternately referred to these patients as cases of delirium and as cases of psychosis Their behavior included becoming restless, maniacal suspicious uncontrollable, and disoriented, getting out of bed, having auditory and visual hallucinations taking the patches off, and talking incoherently The psychoses began from twenty four hours to six days after the bandages were applied In five cases the delirium occurred

during the daytime in six during the night but in every case the symptoms were more prominent at night (p 1175) The symptoms dissipated for 7 of the 11 patients by the end of hospitalization

Harbridge (1914) studied a particularly elderly group seven patients all of whom were 80 years of age or older He followed these two men and five women during the convalescent period and reported very severe secondary effects which included becoming a complete physical wreck death acute mania and depression

Bruns (1916) reviewed 603 extractions performed in one clinic from 1893 until 1915 the interesting feature being that beginning in 1908 most patients were sent home immediately following surgery Most patients whether confined to the hospital or sent home had only the operated eye patched Those sent home were advised to rest in bed or in a reclining chair and to make daily visits to the clinic in the company of another person Cases in which vitreous substance was lost from the eye chamber remained in the hospital Of the 371 cases confined to the hospital between 1893 and 1908 39 or approximately 10 percent were medical failures as contrasted with 18 or 7 percent of 232 ambulant cases treated from 1908 until 1915 Medical failures included infection damage from accidents and all other physical complications In addition Bruns indicated that there were several cases of postoperative dementia among the hospital patients and none among the ambulant cases Dementia refers to what Parker (1913) called delirium or psychosis and in at least three of Bruns cases the patients killed themselves

Brownell s (1917) complete review of cataract patients seen at the clinic of the University of Michigan from 1904 to 1917 included those cases previously reviewed by Parker (1913) A total of 962 patients were included 610 men and 352 women of whom 30 24 men and 6 women had delirium Thus approximately 4 percent of the men 2 percent of the women and 3 percent of the total population had delirium Again the average age of the delirium patients was 72 with a range from 51 to 85 years

The main cardinal signs which should always be watched for are increased irritability restlessness slight irrationalities of speech purposeless movements of the hands and incoherence (p 283) Brownell also included symptoms of disorientation ideas of persecution maniacal behavior visual and auditory hallucinations delusions and illusions In 19 cases the symptoms began at night in 10 during the day and for one patient there was no information They usually began within 2 or 3 days of surgery with a range from the first to the twelfth day The symptoms usually lasted from 1 to 2 days Once again the range was great from a few minutes to weeks

Fisher (1920) reviewed both the English and European literature and added that he had seen four cases of delirium out of 200 cataract opera

tions He presented one case in detail, a 64 year-old man whose behavior was remarkably similar to some of the cases described more recently by Ziskind, Graham Kuninobu and Ainsworth (1963) During the eleventh night following a second cataract surgery, the patient became loud, tried to get out of bed, tore the restraining cords from his hands and took off the bandages from his eye After he quieted down the bandages were re placed, and he soon became agitated again

> Finally he seemed to wake up and when he recognized those around him and knew he was in the ward he told the nurse he had been dreaming and was glad he woke up He then went to sleep and did not wake up until morning when he related the dream and stated that he must have been insane He said he thought he was at a spiritualistic meeting where he was blindfolded and bound in such a manner that he could not move and feared being killed He said that with one heroic effort he broke the ropes that he was tied with and then tore the bandage from the eyes and was going to jump out of the window when he woke up (Fisher 1920 p 745–746 with permission of the American Journal of Ophthalmology)

The relevance of this patient s behavior to his dream is apparent, and it is this parallel which Ziskind has noted in his patients

Lowe (1922) reported a single case of acute mania in an 82 year-old woman during the second night following cataract surgery She had not slept the previous night and was wearing only one patch when she became noisy, violent, and unwilling to go back to bed This behavior occurred again the following afternoon On each occasion she was controlled by medication and there was no damage to her eye

Another single case diagnosed as acute delirium following a cataract operation, was presented by Pfingst (1923) This 60 year-old woman had both eyes patched During the third night following surgery she tore her hair and the bedclothes tried to get out of bed, claimed that someone was trying to get her and said that the house was on fire She subsided when the bandage was removed from the unoperated eye Pfingst reported that he had also seen three cases of acute mania following cataract surgery and that these latter patients did not respond to having one patch re moved.

Thomas (1926) review of the literature included disturbances subsequent to other forms of surgery He concluded the following with re spect to the symptoms "The kind of disturbance varies from the mildest and most transient delirium to acute and violent mania which may be permanent or may end in death The vast majority of the cases however lie between these two extremes, and may be called 'simple delirium with or without hallucinations (p 135) He added two detailed case histories of women with cataracts aged 60 and 68 which are similar to a number of those previously described

Bailey (1928) reported an interesting variation in technique Rather than operating in a surgical suite, he extracted 26 patients cataracts either in their own homes or in their hospital bedrooms His purposes were to reduce the need to move the patient around and to take advantage of the patient s familiarity with his surroundings His patients had both eyes patched for 5 days Of the 20 patients operated upon at home and the six in their hospital rooms he found that these patients were happier, easier to take care of and that there were no instances of cataract mania

Preu and Guida (1937) commented upon the loose usage of terms like delirium acute mania dementia and insanity They offered detailed case descriptions of four cataract patients, two men and two women aged 67 74, 56 and 83 years. These patients had both eyes patched Three patients had special nurses, and all four patients had a psychiatric consultation Within 3 days following surgery these patients exhibited a number of the usual symptoms which included being restless getting out of bed, expressing suspicious ideas being fearful and afraid hearing illusions and seeing objects and scenes which were not present These experiences or symptoms were transitory for three of the patients They were in good condition when discharged and were considered examples of psychosis with the further diagnosis of psychogenic panic The fourth patient had a history of previous difficulty still had symptoms when discharged and was considered psychotic with the diagnosis of organic (senile arteriosclerotic) mental disorder The emphasis of this article was upon the need to make meaningful distinctions between different types of patients by employing a psychiatric approach

Boyd and Norris (1941) were also interested in the diagnostic problem

> Various authors have disagreed sharply regarding some features of the syndrome and this has been due largely to the fact that they were discussing different disorders Some of these observers were reporting cases of transitory delirious reactions due either to emotional stress or a toxic process These psychoses were usually short in duration presented extremely disturbed and dramatic behavior and generally eventuated in recovery unless some fatal accident intervened The other authors were observing cases of senile dementia occurring in aged individuals with impaired central nervous systems the operation serving as the final precipitating factor (p 130 with permission of the Journal of the Indiana State Medical Association)

Boyd and Norris further illustrated what they meant by transitory delirious reactions by presenting the case of a 61 year-old woman who had both eyes patched following surgery This case is similar to many of those already reviewed

A more recent and quite frequently cited case is the one presented by Bartlet (1951) The patient was 84 years old partially deaf and hospi

talized for his second cataract surgery The report contained an extensive description of his many illusionary visual hallucinations' This term was apparently used to indicate that the patient did not believe that these visual images were real, and that in some instances the things which he reported were distortions of stimuli in the room The visual phenomena took place when his operated eye was patched and his other eye was open, although vision in this open eye was very poor

An EEG was recorded while he was seeing faces and people, and it showed no change from the previous record

> The visions seemed to be of two types—one that occurred on a blank wall or ceiling often consisting of people which he could displace at will by moving his eyes and the other of the nature of building of bizarre wire formations which he could not move or could displace only a few inches in one direction On moving his eyes away from the place where it was first seen it vanished (p 366)

This patient did not have auditory effects but on one occasion he said he felt he was 'out of himself' and in another body, and on two occasions he described a sensation as if fluid were bubbling down the inside of his legs (p 368)

A particularly interesting aspect of this case is that on separate occasions he was given 3 grains of sodium amytal by mouth 0 2 grams of mescaline sulfate by mouth 2 ounces of whiskey in 3 ounces of water, and one half ounce of Easton s syrup in 3 ounces of water, the latter being used as a control for the first three tests There was no increase in visual phenomena following administration of the syrup but each of the first three preparations increased visual phenomena During the sodium amytal period a 12 dioptre lens was put over his open eye and the visual phenomena disappeared This procedure was repeated during the mescaline period and while the previous visual phenomena initially disappeared other visual phenomena developed quite soon

There are three relatively recent reports in which reviews were combined with case studies They will be considered at this point only with respect to the classification of the observed behaviors Weisman and Hackett (1958) rejected the term cataract delirium because in their opinion the delirium is more related to the patching than to the cataract Consequently they preferred the term black patch delirium Flynn (1962) believed that In nearly all respects the sensory deprived patient is experiencing a schizophrenic like syndrome while the patient with acute or chronic brain disease is not (pp 62–63) Stonecypher (1963 p 607) on the other hand stated The evidence is that the black patch psychosis is simply an acute form of senile psychosis He then distinguished between senile psychosis and senile dementia the latter being due to organic brain deterioration

Let us conclude this section by briefly summarizing each of the main considerations How frequently do eye surgery patients have symptoms or

experiences similar to the ones reported in this literature? There have been numerous case reports by different physicians over a period of many years Discussions of such cases have usually led to mention of additional cases and these discussions have often implied that the phenomena occur often Surveys of medical records however have indicated very small frequencies 3 percent or less Whether these survey results actually do deviate from what the authors of case reports have implied is uncertain It is clear however, that these frequencies are very much smaller than those which will be reviewed for later investigations

The experiences and symptoms obviously have included a wide variety of sensory cognitive emotional and motor behaviors ranging from the mild to the very extreme A host of diagnostic and categorical labels have been applied most of which are not very revealing and in some instances are quite misleading

Some reported experiences occurred the day of surgery while others did not begin until 2 weeks later The first few postoperative days were the ones most frequently cited Experiences have started both during the day and the night although some reports indicated greater incidence during the night The duration of experiences has varied greatly from those lasting a few moments to those extending beyond the period of hospitalization The majority however were reported as terminating prior to leaving the hospital

The patients have included both men and women and the ages given ranged from 35 to the eighties Most patients probably were over 60 which is typical of those being hospitalized for cataract surgery Moreover some patients had additional medical problems and a few patients had severe problems

Information about deprivation variables was often missing or incomplete It is clear that some patients had both eyes patched while others had only the operated eye patched Some were in lighted rooms others in darkness some alone and some with other people Most had restrictions placed on their movement and were required to remain in bed but again there was considerable variation

Explanatory Variables

Most case history reports and reviews include the authors conclusions about the causes of the reported behavior These conclusions are based upon the authors clinical experience and upon their reviews of the experience of others Thus although these conclusions have had important clinical implications they are subject to all of the problems of a clinical case history approach

In addition these writers have been interested in explaining certain behaviors or symptoms which appeared as potential obstacles to normal recovery from surgery They have not been interested in studying sensory

deprivation variables *per se* Consequently, one does not find experimental manipulation of variables but rather very complex heterogeneous clinical situations which contain a multitude of potential explanations Out of this context different clinicians have chosen a number of variables and have come to a variety of conclusions

Finlay (1904) Thomas (1926) and Stonecypher (1963) have argued that eye patching is not a significant cause of the reported behaviors while others have given it considerable importance (Bruns 1916, Pfingst, 1923, Greenwood 1928 Bruner, 1935, Weisman & Hackett 1958, McRae, 1964) Although there have been many comments about the difference between having one and two eyes patched, the significance of this difference cannot be determined from these reports One important and somewhat neglected consideration is the amount of vision which patients have in their unoperated eyes while they are wearing single patches on their operated eyes Some of these patients were blind in the uncovered eye while others had quite useful vision The effects of visual deprivation from the eye impairment itself and the interaction of the degree of eyesight with patching also are unanswered questions

Still another aspect of visual deprivation is the association of time of day to the reported behaviors Finlay (1904) and Thomas (1926) indicated that darkness is not required Colman (1894) regarded darkness as contributing to the indefiniteness of sensory impressions which in turn leads to illusions Weisman and Hackett (1958) who supported a sensory deprivation approach, and Stonecypher (1963) who vigorously rejected it both indicated that the reported behaviors are more frequent at night

> Despite the fact that both eyes are covered the delirium is apt to be more severe at night This is the time when a hush falls on the ward and auditory cues which may have been responsible for alerting and orienting the patient during the day are replaced by silence with an occasional whispered conversation and the soft sporadic sounds of the night Under these circumstances somewhat analogous to sensory deprivation misinterpretations may become delusions and anxiety may become panic (Weisman & Hackett 1958 p 1285) with permission of the New England Journal of Medicine)

Stonecypher (1963) gave more emphasis to the symbolic meaning of night

> Night is associated with the uneasy feeling of danger ghosts death criminal activity Just as a man who has been reading a ghost story walks uneasily through the house at night the old person who is unconsciously worried about the imminence of death finds night especially after surgery a difficult time during which to control his terror His illusions of invulnerability have been temporarily shattered by the surgery He is lying in a strange world where pain and death are commonplace Everything around him is dark He hears hushed and menacing noises—footsteps in the hall the rolling wheels of a dressing cart groans of a patient At the mercy of strangers he is terribly aware of his own vulnerability (p 608 with permission of the American Journal of Ophthalmology)

Harlan (Kipp 1903) placed the responsibility for psychotic episodes upon homesickness associated with the change from familiar surroundings to the strange conditions of the hospital This proposal was not accepted by Finlay (1904) Bruns (1916) Thomas (1926) and Bailey (1928) all supported the importance of familiar surroundings Their chief evidence was an alleged reduction in unusual behaviors when patients were operated upon in their own homes in their hospital bedrooms or when they were allowed to go home immediately after surgery An important methodological problem with this evidence is that patients at home probably were not as frequently observed by professional staff Although one would expect that the very extreme behaviors would have been reported to the physicians many less extreme or transitory disturbances may have been overlooked or for reasons of social acceptance even deliberately concealed

Restrictions upon movement bedrest and the body positions while lying in bed have not been explicitly proposed as explanations in the literature but their significance has been implicitly supported by frequent recommendations to get the patient up as soon as possible Both Allen and Dillinger referred to the significance of movement in discussing the presentation by Boyd and Norris (1941)

The importance of psychological stress and the variables contributing to psychological stress have been emphasized by many writers (Colman 1894 Posey 1900 Thomas 1926 Boyd & Norris 1941) The reported sources of stress range from the discomfort of a too full bladder (Brownell 1917) to the accumulated conflicts and problems of an aged person which may precipitate a senile psychosis (Stonecypher 1963)

It also is not surprising that considerable attention has been given to the following drugs and alcohol toxic conditions diseases and neurological impairment Colman (1894) did not include cases in which he believed drugs or alcohol were influencing factors Posey (1900) Finlay (1904) Fisher (1920) and Thomas (1926) ruled out atropine as the responsible variable Parker (1913) dismissed cocaine and codeine as important for his cases Fisher (1920) also eliminated alcohol and Thomas (1926) stated that the anesthetics were not the causative factors

What can be concluded about the influence of drugs? The above references do not begin to cover the gamut of medications which may be given to eye surgery patients Moreover the author of this chapter has worked with ophthalmologists who are quite convinced that the reported behaviors are a function of drug induced states The best which can be said at this point is that drugs have been frequently considered by clinical investigators and there is no evidence to support the contention that a significant number of the reported behaviors were caused by drugs Obviously some drugs can cause many of the behaviors described and perhaps some eye patients are so influenced But it is equally clear that many other

eye patients received the same drugs and no unusual behaviors were reported Thus whether drugs are a significant factor remains an important question

Toxic reactions have been frequently considered and dismissed also, but one can only conclude that known toxic reactions were not present The typical statement was that an analysis of the urine revealed no abnormalities (Parker, 1913, Brownell, 1917, Lowe, 1922) By contrast, Finlay s (1904) case had a diagnosed toxic uremia and Thomas (1926) concluded that some cases might be due to a toxic condition resulting from retention of urea and other nitrogenous metabolic endproducts Most writers have regarded these as the exceptions

A number of potential additional causes have been considered diseases (Colman, 1894), neurological impairment (Mills & Camp, 1905, Boyd & Norris 1941) previous mental disorder (Posey, 1900, Thomas, 1926), alcoholism (Brownell, 1917), premorbid personality (Weisman & Hackett, 1958), old age (Harbridge, 1914, Bruns, 1916, Brownell, 1917, Thomas 1926 Greenwood 1928 Weisman & Hackett, 1958) and an insufficient doctor patient relationship (Weisman & Hackett, 1958) There is insufficient evidence to support the relevance of any of these variables, but this, of course, does not rule them out

The report by Brownell (1917) is particularly deceiving, and unfortunately it is frequently cited He surveyed the records of 962 patients and concluded that in the 30 cases of delirium syphilis was not a factor because so far as our records go there were no positive Wassermanns (p 283) This report did not include the percentage of patients who had Wassermann tests, and there was no indication that they were done routinely Brownell considered alcoholism important because ' 36 6 percent of those having deliriums drank to a greater or less extent (p 283) Not only did he label all drinking as alcoholism, but he did not report figures for the nondelirium patients Brownell considered age to be the most important variable because the average age of the delirium patients was 72⅓ years while the average for the nondelirium patients was less than 70 This ' difference was not evaluated statistically, and more important, the numerical difference probably consisted only of a few years at the upper end of the age range The age question is especially important because old age continues to be cited as a cause of delirium in cataract patients despite the lack of any substantial supporting evidence

Prevention and Treatment

First we will consider suggestions for the prevention of disturbing experiences and then suggestions for treating patients who are having such experiences Some of these methods directly involved stimulation variables Some did so indirectly, while others pertained entirely to different variables

Prevention Methods of prevention have included screening patients ahead of time insuring their best overall physical condition preparing them psychologically maintaining familiar stimuli increasing stimulation providing good nursing care and utilizing drugs

A number of variables have been advocated for screening patients who would be likely to have postsurgery disturbances Harbridge (1914) advised against operating on the very elderly unless absolutely necessary Thomas (1926) indicated that previous episodes of delirium and the patient s attitude toward surgery were important indications of later difficulties He postponed surgery if the patient believed that it would do no good that he would die etc Boyd and Norris (1941) also advocated evaluating the total patient and postponing surgery if the patient was emotionally upset Preu and Guida (1937) evaluated patients with respect to previous psychiatric conditions and brain damage McRae (1964) also assessed the patient s personality adjustment in an effort to determine relative ego strengths and weaknesses The most explicit list of screening indicators has been offered by Stonecypher (1963) He stated that patients over 60 would be more likely to develop postsurgery psychosis if they were characterized by two or more of the following a history of marginal social adjustment a long standing disease a history of previous psychotic episodes in the hospital an appearance of frailty and helplessness status as an immigrant occupation of manual laborer and retired By contrast he gave the following as contraindicators an occupation in which one primarily works with ideas (e g lawyer banker etc) familiarity with hospital life previous experience in a similar crisis without psychotic episode and status as a very important person

The need for the patient to be at his best overall physical condition was discussed by Boyd and Norris (1941) and probably was assumed by many other writers Thomas (1926) specifically advised a urinary examination including a test for renal function and perhaps additional blood tests to determine nitrogen retention

Preparing the patient psychologically has been considered especially important Thomas (1926) Preu and Guida (1937) and Boyd and Norris (1941) have all explicitly emphasized the need to explain the surgery in advance and to provide as much reassurance and support as possible Stonecypher (1963) advised against putting these patients in rooms with patients who have had depressing medical histories Weisman and Hackett (1958) emphasized the importance of the doctor patient relationship one of its functions being to provide psychological and emotional support Of course many of the presurgery procedures and patient staff interactions have the potential for providing support to the patient

Preventive measures related to retaining familiar stimuli or to increasing the patient s familiarity with his surroundings have been fre

quently discussed Suggestions to operate in the patient's home or in his hospital bedroom are primarily for this purpose (Harlan in Kipp, 1903, Bailey, 1928, Bruner, 1935, Preu & Guida, 1937) So, too, are suggestions to send the patient home immediately after surgery (Bruns, 1916) or to admit the patient to the hospital 2 days in advance of surgery (Stonecypher, 1963) Stonecypher and others advised putting immigrants in rooms with patients who speak their language Other suggestions have included providing familiar foods for subcultural groups (Weisman & Hackett, 1958, McRae, 1964), supplying radios and allowing the patient to bring personal possessions from home (Stonecypher, 1963, McRae, 1964)

Another method of maintaining and increasing stimulation is to leave the unoperated eye uncovered (Bruner, 1935, Boyd & Norris 1941, Stonecypher, 1963, McRae, 1964) Stonecypher also suggested leaving a light on during the first couple of nights after surgery, a procedure which has been used from time to time by many clinicians By contrast, an earlier procedure was to put the patient in a darkened room (Brownell, 1917)

Although many writers have testified to the particular importance of preventive nursing care, the specifics have not been well delineated (Brownell 1917, Bruner, 1935, Preu & Guida, 1937, Boyd & Norris, 1941, McRae, 1964) In general, it has been advocated that the patient's physical comfort be insured, that minor annoyances of any kind be eliminated, that the patient be given encouragement, and that he not be alone With respect to the latter, McRae (1964) and Stonecypher (1963) also suggested that a member of the family stay with the patient

The final preventive measure to be considered is the use of drugs Brownell (1917) reported that for a time bromides were given to all patients in order to prevent delirium, but that this was not effective Preu and Guida (1937) gave small doses of morphine and scopolamine following surgery in order to prevent pain Both Boyd and Norris (1941) and McRae (1964) warned that larger doses of sedatives should be avoided as they may precipitate a delirious state The use of drugs as a means of treating the patient after disturbing experiences have occurred will be considered later

Treatment Suggestions for treatment have included some of the measures suggested for prevention Among them were maintaining the best possible physical health using psychological support and reassurance, increasing stimulation, providing good nursing care, and utilizing drugs In many instances some combination of methods has been employed

Colman (1894) and Boyd and Norris (1941) specifically included treatment which was directed toward improving the patient's general health as a means of reducing disturbing experiences Some other writers probably assumed this too

Brownell (1917) Thomas (1926) and Preu and Guida (1937) mentioned the use of reassurance although what this consisted of was not

spelled out Boyd and Norris (1941) were somewhat more specific they advised that the patient s lucid periods be used to convince him of the unreality of his hallucinations and that all possible means be used to increase the patient s reality contact

Several of the recommendations have resulted in increased stimulation One of the most frequently mentioned was that the patch from the unoperated eye be removed (Brownell 1917 Pfingst 1923 Thomas 1926 Greenwood 1928 Wilson 1931 Bruner 1935 Preu & Guida 1937 Weisman & Hackett 1958 McRae 1964) Boyd and Norris (1941) suggested using those forms of occupational therapy which did not require the use of vision Still another method which they as well as Brownell (1917) sometimes used was to allow the patient to get out of bed The suggestion to send the patient home to familiar surroundings also increased meaningful stimulation (Kipp 1903 Thomas 1926 Boyd & Norris 1941)

A number of writers have emphasized the importance to the patients of the presence of nurses or relatives (Posey 1900 Kipp 1903 Fisher 1920 Thomas 1926 Wilson 1931 Preu & Guida 1937 Boyd & Norris, 1941 Weisman & Hackett 1958 McRae 1964) Once again the nurse s actions were not well delineated but suggestions included attempting to arouse the patient as soon as the delirium started reducing discomforts as much as possible and restraining the patient when necessary to prevent him from hurting himself

The most frequently cited treatment for experiences has been the use of drugs to relieve pain to induce sleep and to quiet or tranquilize the patient Chief concerns have been the type of drugs to use and the dosage to be employed Posey (1900) gave narcotics chloral and bromides. Harlan (Kipp 1903) advocated hypnotics in large doses Brownell (1917) agreed to the use of hypnotics and favored them over opiates such as morphine and codeine for treating delirium Thomas (1926) gave chloral bromides and large doses of other sedatives when the delirium was well under way Greenwood (1928) prescribed scopolamine and morphine for those deemed actively maniacal Wilson (1931) mentioned that both sedatives and opiates were of value Bruner (1935) gave morphine in large doses for mania and indicated that paraldehyde had not been effective Preu and Guida (1937) warned against the danger that sedatives would produce toxic delirium in the elderly Where necessary they advised moderate doses of paraldehyde as a sedative and small doses of morphine and scopolamine for very excited patients Boyd and Norris (1941) were also concerned that sedatives could produce delirium and warned that small repeated dosages could produce toxic effects Stonecypher (1963) advised using paraldehyde as soon as the patient became disoriented

Finally we shall consider Weisman and Hackett s (1958) interesting approach which included several methods It should be noted that they were called in as psychiatric consultants only for patients who were dis-

turbed upon admission or who were expected to have difficulty following surgery

> In this study the goal of therapy was not the relief of psychiatric symptoms by the systematic investigation of conflict but the prevention and treatment of delirium by correction of faulty reality testing This was brought about in three ways A specific type of doctor patient relation in which the therapist could be accepted as an ally in mastering the stress of the operation and of the masking was fostered He supplemented the patient s impaired vision by providing auditory gustatory tactile and olfactory perceptual cues By repeated explanations encouragement and description he also supplied a conceptual framework to accompany the accessory perceptual reorientation Finally the doctor supported the functions of reality testing by concentrating on an area of the patient s life in which the ego had operated at maximum efficiency (p 1287 with permission of the New England Journal of Medicine)

Although many methods of prevention and treatment have been proposed it is most difficult to evaluate their effectiveness Proponents of each method have sometimes been quite enthusiastic and have stated that in their experience a method was successful Once in the literature each method has been mentioned again and again in subsequent articles and reviews sometimes being stated with more certainty than in the original articles Probably few would disagree with the advisability of insuring the patient s best possible physical health before surgery and attempting to maintain it after surgery preparing the patient psychologically ahead of time and later providing reassurance and support if disturbing experiences occur maintaining good nursing care at all stages and so forth In spite of this general agreement there has been no investigation in which one or more of these methods were specifically related to preventing the development of disturbing experiences or ameliorating them once they had occurred Some may believe that the relationships are so apparent as not to require systematic verification but the present writer is not of this persuasion

There has been more disagreement about the advisability of leaving the unoperated eye unpatched after cataract surgery unpatching the unoperated eye when disturbing experiences develop and using drugs either before or after experiences develop The weight of opinion probably has been for unpatching but there have been numerous instances of lack of success For a variety of reasons earlier writers probably relied more heavily upon drugs than those who have reported recently but this is definitely a subjective impression

Some methods have been obviously related to the various writers beliefs about the causes of disturbing experiences particularly in the case of sensory deprivation variables For other methods the relationships to potential causes have not been so apparent In either case the effectiveness

of different methods rests upon individual clinical reports and an objective evaluation awaits systematic research

RECENT INVESTIGATIONS

Four groups of investigators have conducted one or more studies and in some instances have published related theoretical and review papers. Most of the subjects have been patients hospitalized for cataract extraction or for repair of detached retina. These studies have the following advantages over previous reports: (1) the group of patients to be studied was designated in advance and the incidence of unusual or disturbing experiences recorded rather than only reporting about patients who had experiences (2) larger numbers of patients were studied than in previous case reports (3) data were elicited by direct observation and from patient interviews rather than from clinical records alone as was true of previous surveys and (4) more consideration was given to the usual concerns of research methodology.

The above characteristics taken as a whole clearly separate recent studies from previous reports and they contribute to the value of more recent findings. Although it is important to note the improvements which have taken place, it is even more important to recognize the serious methodological deficiencies in existing clinical studies. The improvements given above are so basic that they would simply be taken for granted in a laboratory setting. As a whole the methodology of clinical studies has been quite inferior to that of recent laboratory studies. Some of these deficiencies will be mentioned in discussing specific studies and a subsequent section will include suggestions for methodological improvements.

Mount Sinai Hospital, New York City

Linn and his associates published two reports of their study (Linn et al 1953, Coles & Linn 1956) and one general review article (Linn 1965). They studied 21 consecutive admissions to the ophthalmologic ward of a large city hospital. These patients were admitted for cataract surgery and most of them came from a home for the aged. The 11 men and 10 women ranged in age from 45 to 85. The median age was 75 and 18 were at least 70 years old.

Each patient had an electroencephalogram and a sodium amytal test upon admission in order to determine organic brain disease. Both eyes were patched from 5 P.M. until 11 P.M. on the night preceding surgery and at 11 P.M. the patient's orientation was tested. Presumably the patches remained on until the patient was interviewed the following morning, although there is some ambiguity about the length of this inter

val Linn et al (1953, p 282) stated "twenty of the patients were masked for a minimum of 12 hours during the night preceding the operation,' while Coles and Linn (1956 p 112) reported for the same preoperative period ' the patient was only masked for about ten hours '

Surgery was conducted with local anesthesia following which both eyes were patched Medication was given for pain and for sleeplessness The patch was removed from the unoperated eye on the third postoperative day, except for those cases where it was removed earlier in order to counteract restlessness It is not clear whether most patients had binocular patches for a full 3 days or for between 2 and 3 days Similarly, the details of the data collection procedures were not given hut in general the patients were interviewed each day and they were observed around the clock by their nurses Additional interviews were conducted with the patients friends and relatives

Twenty of the 21 patients showed some alteration of behavior during the period of hospitalization, such as changes in mood psychomotor disturbances delusions hallucinations disorientation and confabulations (Linn et al 1953, p 282) Upon admission most of the patients were moderately anxious three were severely anxious, and one was disoriented for time place and person During the preoperative masking period ten patients exhibited anxiety, three to the extent that the masks had to be removed

Eighteen patients showed some alteration in behavior during the postoperative period in which both eyes were patched The disturbances were considered mild for five patients and severe for 13 Nine patients became increasingly restless tore off the masks or tried to climb over the siderails Six patients had paranoid delusions four had somatic complaints four were elated three had visual hallucinations and two had auditory hallucinations Eight showed spatial disorientation four showed temporal disorientation, and two showed increased anxiety Most patients exhibited more than one of the above disturbances and the disturbances usually began by the night of the day of surgery

After the unoperated eye was unpatched six patients quickly improved Three improved gradually over 48 hours but the disturbances persisted in four patients who had concurrent medical complications Two other patients were most markedly disturbed following the unpatching

Linn et al (1953) reported that the EEG or the sodium amytal tests were abnormal in 18 patients but both were abnormal in only six cases Two patients did not receive the amytal test It was reported that the behavioral disturbances were more severe in those patients for whom both tests were abnormal Coles and Linn (1956 p 112) further stated

Organic brain disease as indicated by the Na Amytal Test and the EEG was present in eighteen patients A definite correlation appeared to exist between

brain damage and the development of disturbed behavior indicating that senile cataract could well be just one more manifestation of a more widespread and extensive degenerative process This factor of organic brain disease is probably of critical *importance in explaining the high incidence of* psychopathology in this group

The relationships of incidence or severity of disturbance to age sex drugs and premorbid personality were examined although no statistical tests were reported The authors concluded that the incidence of disturbed behavior was not related either to premorbid personality or to post operative drugs and that the severity of disturbance was not related to sex *They did contend however that the severity* of disturbance was related to age because *ten out of the 11 patients* over *age 75* had severe behavioral disturbances as compared with three out of the ten under 75

This study by Linn and his associates had several very good features Patients were evaluated upon admission which prevented confusing chronic disturbances with those which began during hospitalization They were observed and interviewed frequently which led to the detection of disturbances which otherwise might have gone unnoticed The effects of a brief period of patching were evaluated prior to the trauma of surgery and an attempt was made to use relatively objective measures of organic brain disease

Nevertheless there were many *problems in the methodology* and *in* the reporting of this study which make some of the authors conclusions difficult to accept The presence and significance of *organic brain disease is* a basic issue *In the body of the first report* Linn et al (1953) *related* the *presence of* brain *disease* to the *severity* of behavioral disturbances but in the summary and in the subsequent report (Coles & Linn 1956) brain disease was related to the *development* of disturbed behavior Coles and Linn did not even mention severity of disturbed behavior in connection with brain disease and consequently the reader probably would infer that brain disease was found to be related to the presence or incidence of disturbed behavior rather than to its severity

The relationship of brain disease to severity of *disturbed behavior* rested on the measurement of *both variables Severity was* determined by the criteria of *persistence intensity* and the presence of *delusional trends* The *reaction* was considered persistent if it lasted more than 1 day and *intense* if it was readily *apparent* (Linn et al 1953, p 282) No information was given about scoring reliability

Brain disease was diagnosed on the basis of either the EEG or the *sodium amytal tests* although once again this was not made clear by Coles and Linn (1956) Linn et al (1953) suggested that the *discrepancies in* the results between the two tests were due *to the tests measuring* different aspects of brain function *Another possibility* would be low validity or reliability of either test

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Due to the possible measurement problems and to the small number of subjects, it would appear that the reported relationship between brain disease and severity of behavioral disturbance must be considered tentative at best. Moreover, even if this was a valid finding for this sample, to what extent can one generalize from patients who were mostly drawn from a home for the aged? The incidence of brain disease in that group may be much larger than in the population of cataract surgery patients who do not live in institutions.

Another central issue is the effect which unpatching the unoperated eye had upon ongoing behavioral disturbances. It is important that six patients quickly improved, but can one attribute the gradual improvement in three patients over a 48 hour period to the unpatching because many of these behavioral disturbances are only transitory anyway? Moreover, other patients continued to have disturbances or even developed new ones. Thus the overall benefit of unpatching for this sample is unclear. In addition, any evaluation of unpatching is ambiguous without information about the degree of sight in the unpatched eyes.

In their summary Linn et al. (1953, p. 289) stated, "older patients are more apt to show disturbances." Once again, there is apt to be confusion between incidence and severity of behavioral disturbance. No data were given for a relationship between incidence or frequency and age, and all but one patient was reported to have some disturbance. The data for severity of disturbance have been given. Because all but three patients were at least 70 years old, the "younger" patients with the less severe disturbances were between 70 and 75 as compared with the "older" patients who were 75 to 85. This may or may not be a meaningful distinction, especially because it apparently was made after the data were examined rather than hypothesized in advance.

Coles and Linn (1956) concluded by offering eight clinical suggestions: thoroughly evaluate the patient's behavior prior to surgery; where indicated, use a trial period of patching prior to surgery to study the patient's behavior; expect disturbed behavior when both the EEG and the sodium amytal tests are positive; when postoperative disturbance is expected, use four to six corneosclerol sutures; when such sutures are used, leave the unoperated eye unpatched; emphasize good nursing care and visits by friends and relatives; get the patient up early; and use sedatives sparingly. Linn (1965) further advised: reduce preoperative anxiety by careful preparation and, if necessary, early hospital admission; give a normal rather than a liquid diet postoperatively; discharge the very anxious patient early; and occasionally it is helpful to transfer a patient from a private room to a two- or four bed room. Linn also offered a series of suggestions when drug administration is necessary and recommended that overtly psychotic patients be operated upon under general anesthesia. The latter apparently is not required for institutionalized psychotic pa-

tients however because Moses and Volk (1965 p 451) performed 77 ophthalmic surgical procedures upon 52 such patients under local anesthesia with little more risk than one would encounter in a normal population

University of Southern California

Next let us consider the studies by Ziskind and his colleagues Ziskind s work is the most extensive clinical investigation to date and he roughly divided it into three stages First he published a review of the literature (Ziskind 1958) conducted a study of bilaterally patched patients (Ziskind Jones, Filante & Goldberg 1960 Filante Goldberg Jones & Ziskind 1960) proposed a syndrome of related sensory deprivation symptoms (Ziskind Graham Kuninobu & Ainsworth 1963) and discussed some of the relevant problems and theoretical considerations (Ziskind 1964a) During the second stage Ziskind studied the clinical effects of providing increased stimulation to eye surgery patients In the third stage he focused upon methodological considerations (Ziskind & Augsburg 1962 Ziskind 1964b) and upon a final review and summary of his total program (Ziskind 1965)

Ziskind and his associates published one report of their study of bilaterally patched patients while it was still in progress (Ziskind Jones Filante & Goldberg 1960) and another report when it was completed (Filante Goldberg Jones & Ziskind 1960) The first report included 88 patients who were admitted to a large county hospital for cataract surgery and ten who were admitted for repair of detached retina These patients are further described in Table 10–1 Patients with cataracts had both eyes patched for 24 hours after surgery while those with detached retina had both eyes patched anywhere from 7 to 14 days before surgery and from 14 to 30 days after surgery The final report included 15 patients with detached retina and 159 with intraocular disease The latter group included 133 patients who had cataract surgery

Data were collected through patient interviews and by direct observation The authors reported the data in absolute numbers and percentages The present writer calculated Chi Square tests where appropriate in order to better review the findings These statistics were evaluated at the 05 level one tail

Ziskind Jones Filante and Goldberg (1960) found that all detached retina patients and 30 percent of cataract surgery patients experienced one or more mental symptoms including hallucinations disorientation and noncompliance behavior Noncompliance behavior consisted of sitting up or taking the eye patches off contrary to the doctors orders The χ (16 27) was significant indicating a different incidence of symptoms between the two diagnostic groups This difference held up in the larger sample (Filante Goldberg Jones & Ziskind 1960) where all

detached retina patients, 28 percent of cataract surgery patients, and 30 percent of all those with intraocular disease (including the cataract surgery patients) had one or more mental symptoms The χ^2 for detached retina and cataract surgery distribution was 28 60, and for the detached retina and intraocular-disease distribution was 26 66 Filante, Goldberg Jones, and Ziskind (1960, p 355) concluded, the frequency and severity of mental symptoms were noted to increase with the length of the period of bilateral patching' They also indicated that age was not an important factor since the average age of the detached retina group was 40 as compared to 62 for patients with intraocular operations Ziskind, Jones, Filante, and Goldberg (1960) merely attributed the greater incidence of symptoms in detached retina patients to the longer periods of patching

Ziskind, Jones Filante, and Goldberg (1960) reported that patients who could not speak English, had hearing defects had a history of alcoholism, or had antecedent organic brain damage had a higher incidence of symptoms The data were presented in Table 10-1, but no data were given for organic brain damage The χ^2 (4 03) for those who could not speak English versus those who could, and the χ^2 (7 43) for those with and without alcoholism were significant, but the χ^2 (61) for those with and without hearing impairment was not significant The latter χ^2 was computed again using only cataract surgery patients and it still was not significant (92) Filante, Goldberg Jones and Ziskind (1960) did not discuss these variables

Ziskind, Jones Filante, and Goldberg (1960 p 894) reported that 'the incidence of hemorrhage during the period of eye coverage was 5

TABLE 10 1 Contributory Factors to Mental Symptoms in Patients With Eyes Bilaterally Patched

	Detachment of Retina		*Cataract Extraction*			
	Patients With Mental Symptoms		Patients With Mental Symptoms		Patients Without Mental Symptoms	
	No	*Percent*	*No*	*Percent*	*No*	*Percent*
Total	10	100%	26	100%	62	100%
Not Speaking English	1	10%	4	15%	1	2%
Impaired Hearing	3	30%	11	42%	18	29%
History of Alcoholism	4	40%	3	12%	1	2%
Average Age	39 years		60 years		60 years	

SOURCE: Reprinted by permission from E Ziskind, H. Jones, W F Filante & J Goldberg *Amer J Psychiat* 1960, 116 893-900.

times as common in the group with mental symptoms as in the group without (Table 10–2) The χ^2 (2 72) was significant, but if one included all eye complications during patching the χ^2 (2 18) was not significant The χ^2 for hemorrhage alone (4 27) and the χ^2 for all eye complications (3 31) using the larger sample of cataract surgery patients of Filante, Goldberg Jones and Ziskind (1960) were both significant Similarly, the χ^2 (7 57) for all patients with intraocular operations was significant Thus although the percentages were somewhat deceptive the data did support the conclusion that eye complications during patching were more frequent in patients with mental symptoms

The greater incidence of mental symptoms in the detached retina patients attributed to the longer periods of patching was a provocative finding but one which must be examined carefully Perhaps the longer *periods of patching simply meant that data were collected over longer* periods of time There certainly was no assurance in either report that the data-collection periods were equal for the different diagnostic groups

Furthermore even a valid difference in incidence of symptoms between detached retina and other diagnostic groups does not justify the conclusions that frequency and severity of mental symptoms increased with duration of bilateral patching or that age was not a factor These issues should have been evaluated with correlations for the data from single diagnostic groups

The problem is that the authors did not treat the data separately for the different eye surgery groups There are too many differences be-

TABLE 10 2 Surgical Complications in Cataract Extraction

		With Mental Symptoms (21 Patients)		*Without Mental Symptoms (59 Patients)*	
		No	Percent	No	Percent
I	While Patched				
	Hyphema	4	17%	2	3%
	Iris prolapse	0		1	2%
	Flat Chamber	1	4%	1	2%
II	Post Patching				
	Hyphema	2	8%	5	8%
	Iris prolapse	0		1	2%
	Flat Chamber	3	12%	5	8%

SOURCE Reprinted by permission from E Ziskind H. Jones W Filante and J Goldberg *Amer J Psychiat* 1960 116 893 900

tween the conditions for detached retina patients and those for cataract surgery patients to simply consider them all members of a binocularly patched group Moreover, because all detached retina patients had symptoms the influence of alcoholism and not speaking English should have been tested upon the cataract patients alone When this was done for Ziskind, Jones Filante, and Goldberg (1960, p 894) does not appear justi χ^2 (4 17) for not speaking English remained significant, but the one for alcoholism (2 19) did not It is unfortunate that Filante, Goldberg, Jones, and Ziskind (1960) did not discuss the influence of alcoholism, English speaking and hearing impairments for their larger samples

A general criticism of both reports is the lack of methodological information For example, no information was given about observer or scorer reliability Similarly, although Ziskind, Jones Filante, and Goldberg (1960) indicated that some patients were studied before patching and some were repatched after discharge from the hospital, no data were given Based on available information, the following conclusion by Ziskind Jones, Filante, and Goldberg (1960, p 894) does not appear justified "Patients were observed, therefore, for the presence of mental symptoms before, during, and after bilateral patching of their eyes, hence, each patient served as his own control "

Through observation, the authors concluded that the patients mental symptoms frequently occurred during sleep or just upon awakening, that is, during periods of reduced awareness This observation was regarded as an important finding, and it very much influenced their later work

Ziskind Graham, Kuninobu, and Ainsworth (1963, p 331) reported a syndrome of six symptoms which occurred during sleep and other periods of reduced awareness, and which they proposed could be used to compare different sensory deprivation experiments " (1) Disturbances of perception, (2) interference with goal directed behavior, (3) confusion, (4) somnolence, (5) anxiety, and (6) restlessness They emphasized the importance of direct observation in order to isolate the above syndrome

Disturbances of perception included visual and other forms of imagery, often accompanied by brief movements The authors contended that these images were not hallucinations because the patient knew they were not real The images also were considered dreamlike but not dreams because they were associated with purposeful movements the content was brief, visual rather than conceptual imagery predominated and frequently there were precipitating factors such as a full bladder One may or may not wish to accept these distinctions

Interference with goal directed behavior referred to the previously mentioned noncompliance behavior It is important to note that usually the patient did not consciously and intentionally take off the eye patches get out of bed etc It just happened

Confusion referred to very brief periods of disorientation, usually occurring during periods of light sleep or just upon awakening. The authors were not referring to the more prolonged, more pronounced states of confusion noted in the review of case studies.

The meaning of somnolence was simply more frequent periods of sleep. Anxiety varied from very mild to very extreme. Restlessness was indicated by frequent movements, requests, and complaints.

The syndrome has not been used for comparative purposes as the authors intended, but certain components have been used by other investigators (Dayton, Traber, Kaufman, & Gunter, 1965, Jackson & O'Neil, 1966). On the one hand it appears to be a very sensitive composite of some behaviors which can be determined through careful observation and questioning. On the other hand, what is the significance of this "syndrome"? Aren't many of these behaviors to be found in hospitalized patients who have relatively normal stimulation? Certainly, restlessness, anxiety, and increased periods of dozing are frequent occurrences. Even the symptom of confusion as defined by these authors appears rather commonplace.

Because the authors associated this syndrome more with reduced awareness than with sensory deprivation *per se*, one might ask if this is its significance. Restlessness and anxiety, however, certainly occur during alert states, but by definition increased sleeping does not. Opinions are mixed with respect to perceptual disturbances (see chapter 4). Probably the best case for reduced awareness can be made for confusion and noncompliance behavior.

If the significance of the syndrome is that all six symptoms occur together under a specific set of conditions such as reduced awareness and not under other conditions, then the data to support this proposal need to be presented. To date the authors have given illustrative examples but no systematic data, particularly no comparative data for different conditions.

Ziskind (1965, p. 939) stated that in the second stage of his research ". . . we found that an increase in sensory stimulation did not appreciably eliminate the symptoms." Unfortunately this work was not published except for a brief summary:

> If sensory restriction were responsible for the symptoms then an increase in stimulation should modify or abolish these manifestations. Augmented stimulation by radio programs, association between the ambulatory and the confined, and continuous bedside presence of relatives were utilized. Female and male wards served alternatively as subjects and controls. These efforts yielded relatively few and inconclusive differences in the incidence of mental symptoms (p. 940).

It is not clear whether Ziskind increased stimulation prior to the development of mental symptoms in order to prevent their occurring whether he increased stimulation after the symptoms had taken place as a

means of eliminating them or both If increased stimulation was provided in advance then one would expect that symptoms due to deprivation would not occur provided that the added stimulation (radios friends visiting etc) truly replaced the deprived stimulation (visual tactile etc) This brings up such questions as what is normal stimulation what are the baselines of stimulation for different individuals and how equivalent are stimuli from different sensory modalities (Jackson 1964)? To rule out sensory deprivation as a direct cause of the reported symptoms on the basis that adding stimulation does not prevent their occurrence would also require answers to these questions

If stimulation was added after the symptoms were in process as a means of eliminating them the situation becomes somewhat different To argue that the symptoms should be eliminated if sensory deprivation was the original cause overlooks the effects of the symptoms themselves A rough physical analogy would be that providing food does not necessarily overcome the effects of food deprivation The occurrence of mental symptoms has many effects on a person which in turn may promote further symptoms Possible effects include among others anxiety generated by the content of the experience anxiety generated by the process of having the experience and the implication that one is going crazy greater attention turned inward feelings of strangeness and alienation from other people loss of confidence in one s basic perceptual functioning implied or explicit censure by those who regard the symptoms as a nuisance or who are afraid of them and so forth In summary although the present writer agrees with Ziskind that the reported symptoms may not be a linear function of sensory deprivation and also that reduced states of consciousness or awareness may be an important variable (Jackson & Pollard 1962 Jackson 1964) to demonstrate this by providing additional stimulation is a difficult task indeed

Ziskind s methodological studies were reported in Ziskind and Augsburg (1962) Ziskind (1964b) and Ziskind (1965) His purpose was to show the importance of the degree of structuring in the instructions to subjects upon their reported visual experiences in one experiment and upon reported dreams in a second experiment In the first experiment 45 normal subjects were asked to describe what they saw during a 10 minute period with both eyes patched Some subjects reported concurrently and others retrospectively Those reporting concurrently were divided into four groups I–IV which varied with respect to the degree of structure in the instructions and those reporting retrospectively were divided into five such groups I–V (Table 10–3) In the second experiment 16 normal subjects were asked to report their first imagery upon awakening in the morning They also were divided into four groups varying with respect to structure of instructions—I III IV & V (Table 10–4)

TABLE 10-3 Imagery in 10 Min Binocular Patching Tests

Degree of Structuring		Concurrent Reports		Retrospective Reports	
		Subject	Response	Subject	Response
I Description of visual fields		E Z	S*	D Z	S
"Describe what you see		D S	S	R L	S
in your visual fields including changes and any		Z S	S	E B	S
images should they occur."		R D	C*	M J	S
		S S	C		
		S R	S		
		C D	S		
		F J	C		
		R S	S		
		S S	C		
	95%	H M			
II "Any images"		S Z	S	J G	C
"Describe any images		E B	C	P B	
you perceive."		G C	S	E R	C
	75%	D B		H S	C
III Multiple choice		L L		M L	C
"Report your thoughts,		C Z	C	M B	
feelings, images and		L Z	C	S S	S
perceptions."		S Z	C	H B	C
		L K			
	70%	N B	S		
IV Experiences		A R	C	M S	
"Report what you experience."		V S	C	F J	S
		A R		L G	C
		R G			
	62%	B G	S		
V No Prior instructions				C L	
				N P	C
				D P	
	25%			A B	

*S = Simple imagery (lines, dots, geometric and more irregular forms); C = complex imagery (objects and scenes).

SOURCE: Reprinted by permission from J. Wortis (Ed.) *Recent advances in biological psychiatry*, Vol. 6. New York: Plenum Press, 1964. Pp. 111-118.

Tables 10-3 and 10-4 are from Ziskind (1964b). He concluded that the incidence of visual imagery and the incidence of reported dreams were proportional with the degree of structuring contained in the instructions. Although the data were in accord with Ziskind's conclusion, the groups were very small and therefore the percentages probably are unreliable. The present writer collapsed the data for the first two groups and the last three

means of eliminating them, or both. If increased stimulation was provided in advance, then one would expect that symptoms due to deprivation would not occur, provided that the added stimulation (radios, friends visiting, etc.) truly replaced the deprived stimulation (visual, tactile, etc.). This brings up such questions as what is normal stimulation, what are the baselines of stimulation for different individuals, and how equivalent are stimuli from different sensory modalities (Jackson, 1964)? To rule out sensory deprivation as a direct cause of the reported symptoms on the basis that adding stimulation does not prevent their occurrence would also require answers to these questions.

If stimulation was added after the symptoms were in process as a means of eliminating them, the situation becomes somewhat different. To argue that the symptoms should be eliminated if sensory deprivation was the original cause overlooks the effects of the symptoms themselves. A rough physical analogy would be that providing food does not necessarily overcome the effects of food deprivation. The occurrence of mental symptoms has many effects on a person which in turn may promote further symptoms. Possible effects include among others anxiety generated by the content of the experience, anxiety generated by the process of having the experience and the implication that one is going crazy, greater attention turned inward, feelings of strangeness and alienation from other people, loss of confidence in one's basic perceptual functioning, implied or explicit censure by those who regard the symptoms as a nuisance or who are afraid of them, and so forth. In summary, although the present writer agrees with Ziskind that the reported symptoms may not be a linear function of sensory deprivation, and also that reduced states of consciousness or awareness may be an important variable (Jackson & Pollard, 1962; Jackson, 1964), to demonstrate this by providing additional stimulation is a difficult task indeed.

Ziskind's methodological studies were reported in Ziskind and Augsburg (1962), Ziskind (1964b), and Ziskind (1965). His purpose was to show the importance of the degree of structuring in the instructions to subjects upon their reported visual experiences in one experiment and upon reported dreams in a second experiment. In the first experiment 45 normal subjects were asked to describe what they saw during a 10-minute period with both eyes patched. Some subjects reported concurrently and others retrospectively. Those reporting concurrently were divided into four groups, I–IV, which varied with respect to the degree of structure in the instructions, and those reporting retrospectively were divided into five such groups, I–V (Table 10–3). In the second experiment 16 normal subjects were asked to report their first imagery upon awakening in the morning. They also were divided into four groups varying with respect to structure of instructions—I, III, IV, & V (Table 10–4).

groups in Table 10–3, and included both concurrent and retrospective reports. The resulting χ^2 (3.15) was significant at the .05 level, one tail. The Fisher's exact test was applied to the concurrent reports and to the retrospective reports separately. Both were not significant. Similarly, the Fisher's exact test for the data in Table 10–4 (collapsing groups I & III and IV & V) was not significant. Thus the statistical analyses provided some support for Ziskind's conclusion, but not as much as examining the percentages alone might imply.

Ziskind (1965) essentially concluded that his research had shown that mental symptoms reported during conditions of sensory deprivation were primarily due to a combination of reduced periods of awareness, precipitating internal or external stimuli and methodological considerations such as the degree of structuring in the instructions. Shurley (Ziskind, 1965, p. 945) discussed this paper and stated, "I can accept Ziskind's conclusion as a serious, partially testable hypothesis, but not more than that. Ziskind's work has been insightful, stimulating, and often was carried out under difficult circumstances. One would have to agree with

TABLE 10.4 Incidence of Dreams Reported on Morning Arousal in Relation to Type of Instruction

Degree of structuring	*Incidence of dreams*	
I Most structured	G D +	100%
"Write down presence or absence of dreams, reveries, or other images on first awakening."	A S +	
	J S +	
	M H +	
	M S +	
III Multiple choice	M K +	50%
"Record your first mental processes on awaking, e.g., your thoughts, feelings, perceptions, images, or dreams."	B R +	
	M G –	
	G O –	
IV Experiences	J G –	33%
"Record the very first experience you note on awaking."	S B –	
	R S +	
V No prior instructions	L T +	25%
"What time did you waken this morning? Did you have any dreams, reveries or images?" (Asked in afternoon.)	Z C –	
	J L –	
	R D –	

SOURCE. Reprinted by permission from J. Wortis (Ed.) *Recent advances in biological psychiatry*. Vol. 6. New York: Plenum Press, 1964. Pp. 111–118.

Shurley however, that Ziskind s published data to date have not been sufficient to support his conclusion

Ziskind s work is important for future clinical investigations His significant findings have included the following more mental symptoms for detached retina patients than for cataract surgery patients more mental symptoms for those who could not speak English than for those who could and more mental symptoms for those who had a history of alcoholism more eye complications during double eye patching for cataract surgery patients with mental symptoms than for those without mental symptoms and a relationship between the degree of structuring of the instructions and reported visual experiences for normal subjects Ziskind has contributed a proposed syndrome of six mental symptoms including noncompliance behavior which previously had not been so identified He has emphasized the potential significance of reduced periods of awareness precipitating internal or external stimuli and methodological considerations for the reported mental symptoms Both Ziskind s findings and his proposals should be incorporated into future research

University of California, Los Angeles

Dayton Traber Kaufmann and Gunter (1965) compared bilaterally patched eye surgery patients with eye surgery patients who were not bilaterally patched The former were considered sensory deprived as compared to the latter There were 41 patients 20 men and 21 women in the first group and 37 patients 20 men and 17 women in the second group They ranged in age from under 20 to over 65 and all were hospitalized on the same ophthalmology unit

Patients were observed around the clock by their nurses and every nurse filled out an Eye Patient Rating Scale for each of her patients each day If one assumes that there were three shifts a day one would estimate that each patient was evaluated by at least three nurses each day This aspect of the procedure was not made clear

The Eye Patient Rating Scale consisted of 13 patient self reports (e g frightened headache tired saw things that weren t there) and 16 nurse observations (e g slept during day incontinent restless diarrhea took bandages off) It was not clear whether observations usually were made before as well as after surgery A subgroup of ten patients however was observed before during and after patching

The authors reported more symptoms of behavioral disturbance for the bilaterally patched patients than for those not bilaterally patched more symptoms for women than for men more symptoms during the evening than during the day more symptoms for those taking medication among the binocularly patched patients more symptoms for those not taking medication among the patients not binocularly patched and in

the subgroup of ten patients more symptoms during patching than either before or after patching These results except for the time of day variable were based on χ^2 analyses reported significant at the 05 level or less Eye patching (sensory deprivation) was considered a partial explanation for the behavioral symptoms

Although the authors presented a number of important interesting comparisons the present writer is unwilling to accept their reported findings as valid The use of χ^2 was inappropriate as the assumption of independence of observations was violated Each patient appeared in an analysis an unknown number of times depending upon how often he was evaluated with the Eye Patient Rating Scale In addition some subjects were included in both the group that was binocularly patched and the one that was not Moreover the tables were difficult to interpret and the absolute differences between groups were often very small For example Under the section nurse observes 1 9 percent more symptoms were noted for the bilaterally patched group of patients than were noted for the unpatched group and under the patient s reports were 1 2 percent more symptoms than for the unpatched group (Dayton Traber Kaufmann & Gunter 1965 p 866)

The above comparison was further complicated because the binocularly patched group included a disproportionately larger number of patients with detached retinas In addition the group not binocularly patched presumably included patients with no patches those with one patch and good vision in the unpatched eye and those with one patch and poor vision in the unoperated eye

The rating scale itself was extremely heterogenous including items such as seeing things which were not there and feeling tired both of which were treated equally as behavioral symptoms Moreover there were no data reported with respect to scoring reliability In summary there simply were to many serious methodological problems to accept the reported findings

Case Western Reserve University

The final research to be considered is that of the present writer and his colleagues Although this work began with laboratory investigations the recent focus has been upon clinical studies one long range purpose is to better integrate the two approaches

The first of a series of studies of eye surgery patients has been reported (Jackson & O Neil 1966) Seventy-eight patients who met seven criteria were included These criteria were subjects were private patients had eye surgery were 21 years of age or older were English speaking had sufficient hearing to be able to communicate verbally had their operated eyes patched for at least two days postsurgery and were

hospitalized at least six days postsurgery (pp 55–56) There were 39 men and 39 women whose average age was 63 years Sixty were hospitalized for cataract surgery, 12 for repair of detached retina, and 6 for other eye surgery

Each patient was interviewed three times, once prior to surgery, once on the second postoperative day, and again on the sixth or seventh postoperative day In addition, the nurse who was designated as knowing the patient best was also interviewed Scripts were followed for each interview, and all of the data gathering interviews were tape recorded Further data also were obtained from the patients records The interviews were transcribed and the patients sensory, motor, cognitive, and behavioral (noncompliance) experiences were scored according to the categories in Table 10–5 Scoring reliability was satisfactory

Half of the patients had at least one experience 33 percent sensory, 2 percent motor, 15 percent cognitive, and 26 percent noncompliance (Table 10–5) Almost all of the detached retina patients had one or more experiences (83 percent) as compared with 45 percent of the cataract patients ($\chi^2 = 4\ 447$, $p < 05$)

Most visual and auditory experiences were structured rather than unstructured when scored according to Zuckerman and Cohen's classifications (1964a) Most experiences were seen or heard clearly, and they were reported by the patients as 'seen through their eyes or 'heard through their ears' as opposed to seeing or hearing them in their imagination When asked whether their perceptions were of real events, however, the patients reactions were quite varied Some believed that they had perceived real events at the time of occurrence but changed their minds after investigating or having others investigate Others persisted in the belief that the events were real or reluctantly gave in to the persuasions of staff, friends or relatives Similarly the patients emotional reactions to their experiences were varied some being quite anxious while others reported lack of concern

The relationships between different types of experiences for the 41 patients who had more than one type of experience are given in Table 10–6 The negative relationship between thinking and noncompliant experiences was an artifact of the scoring system

Experiences were coded for frequency duration, and time of occurrence Sensory and cognitive experiences usually occurred several times or frequently while noncompliance behavior was usually reported only once per subject Noncompliance and sensory experiences lasted 'briefly" (a few seconds to 20 minutes) while most thinking experiences lasted longer than 20 minutes Most experiences started by the second postoperative day noncompliance experiences took place primarily at night while sensory and cognitive ones occurred either during the night or the day

TABLE 10.5 Number and Percentage of Patients Having One or More Experiences in the Total Sample and in the Cataract Versus Detached Retina Subgroups

Category[1]	*Total Sample* *N* = 78		*Cataract* *N* = 60		*Detached Retina* *N* = 12		*Chi*[2]*	*P*
	Number	%	Number	%	Number	%		
Visual	19	24	10	17	7	58		
Auditory	13	17	6	10	4	33		
Body Touch	8	10	2	3	5	42		
Smell	1	1	1	2	0	0		
Taste	0	0	0	0	0	0		
Visual & Auditory	8	10	3	5	3	25		
Visual & Body	4	5	0	0	3	25		
Auditory & Body	5	6	1	2	3	25		
Visual & Auditory & Body	3	4	0	0	2	17		
1 or More Sensory	26	33	14	23	9	75	10.017	<.05
Motor	2	2	2	3	0	0		
Cognitive	12	15	7	12	4	33	2.146	N.S.
Noncompliance	20	26	14	23	5	42	0.915	N.S.
Sensory & Cognitive	10	13	5	8	4	33		
Sensory & Noncompliance	8	10	4	7	4	33		
Cognitive & Noncompliance	3	4	1	2	2	17		
Sensory & Cognitive & Noncompliance	3	4	1	2	2	17		
1 or More Experiences	41	52	27	45	10	83	4.447	<.05

[1] Categories are not mutually exclusive. For example, a patient with visual and auditory experiences was counted in the following categories: Visual, Auditory, Visual and Auditory, 1 or More Sensory, and 1 or More Experiences.

*Chi^2 comparisons are between Cataract and Detached-Retina Subgroups.

SOURCE: Reprinted by permission from C. W. Jackson, Jr., & Margaret O'Neil, in J. E. Jeffries (Ed.), *Disturbances in sensory input in nursing practice and research. Ross roundtable on maternal and child nursing.* Columbus, Ohio: Ross Laboratories, 1966. Pp. 54–69.

TABLE 10 6 Phi Coefficient Correlations Between Types of Experiences for 41 Patients with One or More Experiences

Type of Experiences	ϕ	p
Visual & Auditory	21	N S
Visual & Body	01	N S
Auditory & Body	32	< 05
Sensory & Thinking	27	N S
Sensory & Noncompliance	− 47	<.05
Thinking & Noncompliance	− 31	< 05
Visual & Thinking	48	<.05
Visual & Noncompliance	− 42	<.05
Auditory & Thinking	02	N S
Auditory & Noncompliance	− 01	N S
Body & Thinking	09	N S
Body & Noncompliance	14	N S

SOURCE: *Reprinted by permission from C W Jackson Jr & Margaret O'Neil In J E. Jeffries (Ed) Disturbances in sensory input in nursing practice and research Ross roundtable on maternal and child nursing Columbus Ohio Ross Laboratories 1966. Pp 54 69*

Patients with cataracts were compared with patients having detached retina on a number of biographical sensory, and activity variables Results significant at the 05 level indicated the detached retina patients were younger (55 vs 66) more of them had their unoperated eyes patched and for greater time periods they had better vision prior to surgery as determined by records of visual testing they rated their functional vision higher they had less hearing impairment when rated on a three-point scale they evaluated their own functional hearing higher, and they were detained in bed longer thus having greater restrictions upon their movements

Further comparisons were made between cataract patients who had one or more experiences ($N = 27$) and cataract patients who were reported to have no experiences ($N = 33$) No significant differences were found for biographical variables or for those physical variables (e g temperature elevations blood pressure irregularities urinalysis results etc) and drug variables which could be determined from the hospital charts and records Similarly there were no significant differences for the duration of confinement to bed the number of patients in the room or ratings of activity

Cataract patients with experiences evaluated their own functional hearing lower than those without experiences and they tended to be rated

as having more hearing impairment Somewhat paradoxically patients with experiences had better uncorrected vision in their unoperated eyes and were more likely to have their unoperated eyes unpatched

An assessment was made through interviews and records of the nursing staff's awareness of the patients experiences They were definitely aware of 41 percent of the total experiences scored and of 54 percent of the patients who had these experiences In some instances patients had concealed their experiences from the staff

Further findings were reported with respect to nursing actions and research methodology which will not be detailed here In summary Jackson and O Neil (1966 p 68) concluded

> Some of the present findings support a sensory deprivation explanation of the reported experiences while others do not In support of sensory deprivation detached retina patients had greater visual deprivation and more restricted movement than cataract patients Also most experiences started by the second post operative day or during the period when visual deprivation and restricted movement are greatest Furthermore cataract patients with poorer hearing were more likely to have reported experiences than those with better hearing Other findings fail to support sensory deprivation There were no significant differences between the cataract patients with and without reported experiences on social isolation restricted movement or most of the other sensory variables Most experiences except for noncompliance behaviors were as likely to occur during the day as the night Moreover cataract patients with experiences were more likely to have their unoperated eyes unpatched and to have better vision than the cataract patients without reported experiences Some patients reported similar or analogous experiences during previous hospitalizations and even some under relatively normal circumstances (with permission of Ross Laboratories)

In a subsequent report suggestions were made for the care of eye surgery patients who may have disturbing experiences (Ellis et al 1968) The focus was upon recommendations for determining whether or not patients are having experiences and for helping patients to cope with such experiences rather than upon prevention The discussion included the following patient concealment of disturbing experiences cues for eliciting such experiences the use of probing questions emotional reactions accompanying experiences the mutual importance of patient staff discussion the significance of patient expectations pitfalls to be avoided potential barriers to further patient staff communications and the use of reassurance and repeated orientation

FUTUPE RESEARCH

In spite of voluminous case reports and a number of recent studies many of the basic questions remain unanswered What is the significance of the reported experiences for the patients and for the staff? Are those

experiences which are overlooked by the staff unimportant, or are they all the more important? What do the experiences *mean* to the patients? We know that many patients have them but how frequently are the experiences *truly stressful?* To what extent is stress due to the content of the experience to the implication that one might be going insane or to the fear that further damage has been done to the eye?

What causes these clinical experiences? Is it sensory reduction *per se*, a significant deviation from a person s optimal stimulation, or perhaps an altered state of consciousness induced by sensory reduction? What is the influence of physical variables drugs and the many other potentially powerful variables found in a hospital situation? Moreover, what accounts for the great variability of responses found among patients? Considerable variability is also a characteristic of experiences reported for laboratory subjects (Jackson & Pollard 1962)

How can one predict which patients will have experiences and how can one help patients cope with them once they occur? How important are age personality, and other personal variables? Can disturbing experiences be prevented or at least can the patient s reactions to the experiences be influenced? For example what would be the effects of systematically informing patients ahead of time about the possible development of such experiences? Would such information frighten some patients reassure others who later developed experiences or perhaps even increase the incidence of experiences?

The questions above by no means exhaust the relevant clinical issues Furthermore with the advent of more objective more replicable laboratory findings the opportunity may arise to test these findings in the clinical setting and to develop appropriate applications

Methodological suggestions for future clinical research might read like a primer of research methodology Better research design more appropriate statistical analyses clearer reporting of procedures and findings and *replication of results* should be taken for granted Clinical investigators should be especially conservative about assuming a causal relationship between two variables just because they occur together at the same time This alone has led to many misleading conclusions The above is written with the full realization that employing good research practices in a hospital setting is often very difficult and usually requires great cooperation from the many different people who contribute to the patients welfare

There are three topics of special concern defining the dependent variables selecting methods of eliciting the data and the need for comparisons between groups The operational definition of the experiences under study is crucial There is no good system to date Psychiatric terminology is often very misleading (e g psychosis hallucinations) and by contrast the common denominator approach (e g reported visual sensations) is undifferentiating and inadequate Some new conceptual ap-

proach which will permit meaningful relevant distinctions and which will be sufficiently objective for both clinical and research purposes is required

Selecting a method of eliciting the data is also crucial Relying on clinical information from the hospital charts alone is extremely hazardous for research purposes Direct observation and questioning while the experiences are taking place probably elicits many experiences which otherwise would be overlooked and has the potential for better determining the impact the experiences will have upon different patients On the other hand continuous direct observation for research purposes is very expensive and in the past has been of unknown reliability In addition the presence of the observer may either facilitate or inhibit the reporting and perhaps even the development of the experiences

The remaining method is retrospective reporting The disadvantages are obvious Experiences are repressed suppressed and otherwise influenced by what intervenes The advantage is the greater objectivity which results from the use of scripts sequentially structured questions tape recordings and scoring by independent judges In addition some patients report experiences in retrospect which they would be unwilling or unable to report in process

One other important aspect of eliciting data is the use of standard tests particularly paper and pencil tests of personality and the like To use such measures for predictive purposes usually requires adapting them for verbal administration and for the patient population Young well educated subjects were usually used in developing these tests and consequently one has to select such measures very carefully

The final concern is comparisons between groups and selection of subjects One cannot assume that eye surgery patients with different diagnoses can be meaningfully combined according to double patching single patching and no patching This is particularly true for cataract and detached retina surgery patients In addition to considering diagnosis there should be increased use of measures of vision hearing and perhaps of other sensory modalities in order to establish the current sensory functioning of these subjects Such procedures will lead to more comparisons both between subgroups of eye-surgery patients and between those patients who report experiences and those who do not within a particular subgroup

A likely procedure is to compare patients with themselves such as before during and after patching These comparisons for cataract patients ordinarily would parallel presurgery the acute phase of recovery and a more nearly normal state Thus although this method may help control individual differences to patching both the conditions and the patients are changing at the same time Moreover patients who have had experiences early in hospitalization or even in a previous hospitalization may

consequently have quite different reactions later on Even the procedure of repatching patients for experimental purposes should be done with the knowledge that laboratory subjects reported significantly fewer experiences during a second deprivation (Pollard Uhr & Jackson 1963a)

Another alternative is to compare a group of eye surgery patients with a group of relatively nondeprived hospitalized patients Hospitalization itself is of course a form of stimulation deprivation but patients may be selected who are least deprived Although there are many practical problems to this approach it probably has the best potential for better evaluating the influence of sensory reduction *per se* Further comparisons with eye surgery patients which would be of interest include orthopedic and other deprived patients (Jackson Pollard & Kansky 1962) patients having similar experiences whether or not they are sensory deprived (Kornfeld Zimberg & Malm 1965) and people having analogous experiences under more normal circumstances (Jackson & Pollard 1966)

SUMMARY

Eye-surgery patients particularly patients with cataract or detached retina have been the most frequently cited examples of clinical sensory deprivation There is no question that the combination of eye pathology treatment procedures and hospital conditions reduces sensory stimulation It is equally clear that many other potentially influential variables may be present including physical disease psychological stress and drug administration

There have been numerous case studies of patients with disturbed behavior during eye patching reported by many different physicians over a long period of time The reports have included cognitive sensory emotional motoric and behavioral experiences some have been mild while others have been quite severe and detrimental A host of labels have been applied depending upon the era and the orientation of the various writers Many of these experiences appear similar to those reported by normal subjects during laboratory studies of sensory deprivation

The frequency of clinical experiences as determined by early surveys of hospital charts was small approximately 3 percent Frequencies reported in recent clinical studies however have been much higher ranging up to 100 percent for detached retina patients Although the frequencies for cataract patients have been lower the range has been from 30 percent to 95 percent The differences between early surveys and recent studies probably have been due to the more intensive data gathering procedures in recent studies and the inclusion of less severe symptoms as experiences

Many but not all experiences have begun by the second postoperative day They have occurred either during the day or the night although

noncompliance behaviors have been reported as being more frequent at night. Many experiences have been of short duration, perhaps a few minutes, but others have lasted for days or weeks.

Experiences have occurred to both men and women during double patching, single patching, and in rarer instances with no patching at all. The amount of vision in the unpatched eye has often been an important, unknown quantity.

Proposed explanations have varied greatly including, of course, sensory deprivation. Explanations concerning sensory deprivation have usually been focused upon visual reduction, with some attention having been given to hearing loss, reduction in bodily stimulation, social deprivation, and the reduction in familiar, meaningful stimulation due to being taken out of one's customary surroundings. The evidence for sensory deprivation has been mixed, and the issue has not been resolved.

Numerous other explanations have also been proposed. Brain damage, psychological stress, previous mental disorder, alcoholism, toxic conditions, premorbid personality, drug administration, and old age have been frequently suggested. There has been too little consistent evidence to accept any of these proffered explanations, although each has its supporters.

At present one must consider sensory deprivation and other alternative explanations. The concepts of reduced states of awareness and altered states of consciousness are particularly intriguing, although difficult to operationalize adequately.

A number of methods have been advanced either to prevent the occurrence of disturbing experiences or to eliminate them after they have begun. Some methods have been related to sensory deprivation concepts while others have not. The evidence for the effectiveness of different methods rests upon individual clinical reports, and more systematic evaluation is needed.

Recent studies by four groups of investigators have had advantages over previous case studies, but many methodological problems have been apparent. The most consistent finding has been the previously mentioned large percentages of patients reporting experiences. In two studies the frequencies have been significantly larger for detached-retina patients as compared to cataract-surgery patients. Additional findings have included the circumstances under which experiences took place, methodological considerations, and relationships between having experiences and sensory, physical, biographical, and other variables. Recent investigators also have proposed explanations, methods of prevention, and methods of treatment. These findings and proposals require further testing, replication, and verification.

Although there have been many case studies and some more extensive investigations, many of the basic questions are yet to be answered. Fu-

ture investigators should give much greater attention to methodological considerations. With improved methodology very interesting comparisons will be possible between selected groups of eye surgery patients and a variety of both deprived and nondeprived groups. These comparisons and other types of clinical studies have the potential for leading to both theoretical contributions and clinical applications. These goals will be greatly facilitated by a better integration of laboratory and clinical approaches to the problems.

11

Studies of Small Groups in Confinement

Seward Smith

Several years ago on an isolated island in the Pacific Ocean during a scientific test program 60 men lived in a small shack under extremely crowded conditions. The group was congenial at first, but in time morale declined and interpersonal tensions increased. Heavily responsible factors seemed to be the crowded conditions, difficult environment, monotonous routines, and being largely cut off from the outside. One man, who was irritable and argumentative in the face of compounding stresses, gradually withdrew, falling into a depressed state. He began continuous compulsive whistling which quickly became unnerving for the other men who could not easily escape this added annoyance. By the end of the 6-month stay on the island the group was tense, nervous, and irritable, with most of the men virtually hating one another. Thus deprived of many of the usual necessary interpersonal relationships, more than one isolated member of the group found out what it is like to be a part of a "lonely crowd" (H. Smith, 1966, personal communication). This account and many others like it abound in the largely anecdotal literature about groups in isolation. It highlights the fact that having others around to share one's monotonous isolation, while indeed helping to reduce many of the classic sensory and perceptual deprivation symptoms, unfortunately creates many problems as well. The studies of groups in confinement being surveyed here encompass broad ranges of environmental conditions, stressors present, degrees of isolation, durations, group sizes, and the like. Yet a clear and useful thread of information emerges. It is the purpose of this chapter to present this interesting picture. Contributing data to this end are a wide variety of sources: (1) controlled laboratory isolated-groups experiments, (2) studies of isolated duty stations in the Antarctic and Arctic, (3) submarine service habitability and selection studies, (4) ex-

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periments on fallout shelter occupancy, (5) space system tests and other aerospace assessments (6) manned space flight (7) experiments on man in the-sea (8) various reports of expeditions and explorations and (9) accounts of sea voyages and disasters

The ultimate goal of a research summary is to glean useful facts and hypotheses and to avoid unsubstantiated overgeneralizations and careless conclusions The writers of the diverse literature to be cited represent similarly diverse fields and interests Although in a sense such diversities may represent a strength through breadth of outlook it would not be overstating the case to indicate that many of these references lack some of the scientific refinements and controls that lead to more clear-cut interpretation of results For instance most of the studies lack control groups give little assurance that important extraneous variables have been controlled and in many cases occur as a part of larger higher priority study efforts It is the opinion of the writer however that the task of assembling useful research information is not best served by totally ignoring such limited studies

Although this book deals primarily with instances of individual perceptual and sensory deprivation much of the material covered in this chapter falls more in the category of confinement with greater or lesser amounts of sensory and/or perceptual deprivation physical and social isolation hazards and so on Confinement refers to restraints placed upon freedom of movement and action caused by such factors as space limitations weather and other environmental limitations and task requirements Social isolation is obviously relative There is some social interaction possible in all of the group-confinement studies to be presented However depending upon group size the available range is usually quite limited and in some instances contacts outside of the microcosm are blocked Physical isolation conveys the notion of being distant from centers of usual activity and communication inaccessible to help if required etc All of the above conditions may be present in a given confined environment An example would be a small team operating in the hostile environment of the Antarctic out of radio contact Such a group would likely face drastically reduced stimulus inputs and what there was would be monotonously homogeneous Social contacts would be greatly limited and the men would be both physically isolated from their usual world of activities and confined to a narrow surround by environmental circumstances In contrast other occasions of group confinement might not involve appreciable physical or social isolation deprivations or hazards An example would be a habitability checkout involving a crew confined in relative safety having a varied and busy work schedule frequent interactions among crew members and with outside personnel just a few feet away and so on

No attempt will be made to locate the various reported studies on the complex array of dimensions implied and exemplified in the preceding discussion It would be wise to keep such forms of distinction in mind

however, especially when sorting evidence to bear on a particular problem For example, Sells (1966), in seeking the material most applicable to NASA s proposed manned flights to Venus and Mars, concludes that submarines, exploration parties, and bomber crews represent the greatest similarity to the social system projected for such extended duration space missions Other group-confinement experiences such as shipwrecks and disasters, POW situations, and so on, are not deemed to have sufficient relevance from which to venture extrapolations

A final point should be explored before detailing the literature Each isolated duty situation can presumably be placed on distributions representing costs and rewards to the crew (Radloff, 1966, 1967, personal communications) Some missions will, by such categorizations, be glamorous and frontier seeking (e g , space flight or man in the sea), while others such as duty at the DEW (Distant Early Warning) line will be unsung, routine, and monotonous The former mission category requires careful selection, to be sure, but except for extended durations, probably confinement tolerance *per se* needn t be among the most important crew selection criteria It is for the lengthy, unheralded, monotonous confinement category that most of this chapter is assumed to have its greatest relevance As will be revealed, such missions will doubtless be difficult to staff successfully and will be difficult to endure

DATA FROM STUDIES OF GROUP CONFINEMENT

It is generally assumed that fewer problems exist for small groups in isolation and confinement than is so for individuals The presence of at least one other person appears to constitute an enrichment of the isolated environment, making it more tolerable In pronounced contrast to the typical symptomatology described for individuals undergoing sensory or perceptual deprivation, studies of groups in isolation contain far fewer mentions of unusual visual sensations perceptual distortions, difficulties with the boundary between sleep and awakeness, unusual dreams and other abnormal experiences

As noted by Mullin (1960), however, at least three major stresses confront isolated groups First, even a relatively enriched isolated environment eventually palls to boring sameness compared with the variability conventionally available Secondly, because of their interdependence, group members must find ways to get along with one another in what are often crowded and otherwise unfavorable conditions And finally, few of the usual sources of emotional gratification and release are available to group members

Although the environment of an isolated individual is more often described as boring and monotonous this description strongly character

izes group confinement as well. Other things commonly reported are interpersonal frictions, feelings of lowered achievement, reduced efficiency of performance and thought, and barriers to effective teamwork. Interestingly, measured short term performances usually fail to reveal decrements. Members of confined groups often feel considerable irritability and generally become more negative in mood. They also may have problems with sleeping and, in some situations, symptoms of apparently psychosomatic origin are surprisingly prevalent. Reduction in communication and other socially oriented behavior may well occur, particularly in long duration confinements. Lest this appear to be an overly negative picture, it is well to mention that there are wide variations in the effectiveness with which different groups and individual group members are able to handle their confinement experience.

Group Behavior

Interpersonal Stresses. Perhaps as well established as any small group-in isolation finding is that overt or covert interpersonal frictions frequently are a problem. Pronounced irritability, hostility and personality conflicts are reported throughout the literature (see e.g., Agadzhanian, Bizin, Doronin, & Kuznetzov, 1963, Alluisi, Chiles, Hall, & Hawkes, 1963, Brainard, 1929, Burns & Gifford, 1961, Byrd, 1930, 1938, Cavalier, 1962, Cleveland, Boyd, Sheer, & Rettman, 1963, Cowan & Strickland, 1965, David, 1963, Farrell & Smith, 1964, Gunderson & Nelson, 1966, Hagen, 1961, Haythorn & Altman, 1967b, Mullin, 1960, Rasmussen & Wagner, 1962, Reidy, 1953, Rodgin & Hartman, 1966, Tira, 1955, Weybrew, 1961).

An astute observer of groups in isolation during his Antarctic expeditions, Admiral Byrd (1930) had this to say about one manifestation of interpersonal friction:

> Arguments are at once the joy and affliction of the winter night. How many roared through Little America like fire sweeping dry timber I should hesitate to say. But offhand, well, one or two too many. Let the temperature drop to 70° below zero outside, we never lacked for burning issues inside.
>
> Like country cousins, argument clung to us always. They started innocently, gathered increasing strength and became so fraught with passion as to threaten to bring down the roof. They seemed to have no end. Pertinacious minds, reluctant to concede defeat, would trot them forth like horses under raps and start them off again. Then the air would clear, the issue be decently interred, but before its bones had ceased to rattle, a new one was in the travail of birth. Probably the wisest thing we did, when we went South, was to bring a set of the Encyclopaedia Britannica, the World's Almanac and Who's Who. These repositories of essential information were a godsend. That these estimable works happen to have lacked some of the facts that were, for a time, like life and death in Little America is due less to neglect on the part of the editors, I imagine, than to discrimination and perhaps a sense of propriety (p. 210).

In one of the few laboratory studies of groups in confinement employing control subjects, Altman and Haythorn isolated dyads for ten days (Altman & Haythorn, 1965, Altman & Haythorn, 1967a, 1967b, Haythorn & Altman, 1967a, 1967b, Haythorn, Altman, & Myers, 1966) To determine the importance of interpersonal compatibility during isolation, the dyads were deliberately composed to occupy various points on a compatibility dimension The theoretical compatibility of a given dyad was defined by the extent of similarity or dissimilarity of its members on personality test measures of dogmatism and needs for affiliation, achievement, and dominance An example of high incompatibility was a dyad whose members were heterogeneous (one high and one low) on needs for affiliation, achievement and dogmatism and who were both high on need for dominance High compatibility would be exemplified by a dyad sharing low dogmatism and high affiliative and achievement needs, as well as being heterogeneous on need for dominance

The dyads were confined in a small room where they were given a fixed schedule of work each day, but were otherwise cut off from outside contacts Relatively few props were provided to help pass the remainder of the time Similarly composed control-group dyads were tested in an equivalent laboratory room on matching schedules, but lived away from the laboratory, leading a more rich and varied existence

In general far fewer problems were found among the control dyads than among the confined dyads Four of the nine isolated dyads experienced difficulty in the situation, which in the case of two groups led to their failure to endure the full 10 days, and in the others involved severe interpersonal hostility All four of the dyads experiencing difficulties were *a priori* incompatible groups No such problems were found among control dyads, who also reported less subjective stress and emotional symptomatology

Of particular interest to the present discussion, compared with the theoretically compatible isolated subjects the incompatible dyads reported more subjective stress and symptomatology in addition to their greater interpersonal frictions Comparing the theoretically compatible and incompatible dyads within the control condition, however, no differences on these measures were found The results point clearly to the conclusion that interpersonal compatibility is even more important in confined groups than for groups operating in more enriched environments

The study of very long group confinement by Cowan and Strickland (1965) also supports this conclusion A group chosen to be compatible had a demonstrably easier time during their confinement than did another group constituted without regard for compatibility

In another experiment a deliberate selection procedure was employed to obtain a compatible four man crew The group was confined

for 12 and later 30 days in a space cabin simulator (Dunlap undated) Although no control data are available the group appears to have been well constituted with regard to compatibility and is reported to have had no serious personal problems or conflicts

Group Interactions It is generally agreed that the interdependence of members of a confined group blocks many an overt expression of problems created by confinement In such a situation individuals can ill afford to alienate the remainder of the group Many other forms of behavior seem to emerge instead In many instances communication and other interactive activities decline with time and territoriality and privacy needs assume prominence Also many a person is surprised to discover how lonesome he feels even though surrounded by others sharing confinement

The previously mentioned study of laboratory confinement by Cowan and Strickland (1965) involved two groups of six men the first confined for 12 weeks the second (the compatible group) for 6 weeks The groups were isolated in a penthouse atop a university building where contacts with other than test personnel were minimal The experiment was performed primarily to obtain nutritional data but political scientist and psychologist collaborators were heavily involved For instance a psychologist was a known participant observer member of the second group

Many overt signs of difficulty were evidenced particularly by the first group Hostility rudeness uncooperativeness and other manifestations of conflict were accompanied by definite changes over time in group activity The authors refer to cocooning to describe the manner in which subjects characteristically withdrew from group involvements The following are comments made by subjects during the 12 week confinement

> We all felt the need not to express ourselves completely It is close in here at times I don t want to get involved Have to be here for two more months (p 37) you learn to ignore people more I don t *know* anybody up here I have no reason to try I d just as soon not go into any big thing (p 38)
> It is only a group insofar as we have to stay together We wouldn t stay together that s for sure (p 38)

By the eighth week of the 12 week confinement very little group behavior was observed with subjects tending to withdraw more and more What dealings they did have with one another were abrupt Even in the more compatible group undergoing the shorter confinement similar changes were evidenced In the first 4 weeks these subjects spent about 44 to 48 percent of their time in passive group activity (e g reading watching television listening to music etc all in the presence of others) and 31 to 32 percent in active group participation (e g conversation and playing cards) By the end of the sixth week however the subjects were spending about 60 percent of their time in passive group activities com

pared with a reduction to about 20 percent on active group participation Throughout confinement the amount of time spent in solitary activities remained about the same It appears as if subjects had an increasing need to get away from one another but gained at least some reassurance from being in the same room as long as interaction wasn t required

In the Altman and Haythorn experiment records were also kept of the time spent by dyad members in joint and in solitary activities (Altman & Haythorn 1967a) Isolated dyads began with somewhat more joint than individual activity but gradually withdrew from each other over time so that by the end of confinement they were spending about twice as much time in individual as in group activity Though the pattern for control subjects is not so clear by the end of the 10 days they were engaging in more group than solitary activity and hence did not show the gradual withdrawal pattern The authors speculate that the rapid acquaintance process early in confinement may have contributed to the withdrawal of isolated subjects from each other as they discovered incompatibilities

There are instances where persons undergoing limited duration confinement clearly attempt to avoid highly personal or controversial communications seemingly aware that such areas might jeopardize mission success Hagen (1961) for example reports a two-man 30-day space flight simulation during which the Bales Interaction Process Analysis was employed The subjects kept their interactions in the more formal middle categories with considerably less in the more affectively tinged areas

Territoriality the claiming of objects and areas has been observed often in isolated groups Tura (1955) in describing his experiences adrift on a life raft for a month tells how his companion refused to give up their only flashlight even when he became too weak to use it for signalling Neither could Tura bring himself to take it away from the ill man Had either of these events taken place it is likely that rescue could have come soon enough to spare the life of Tura s companion

Experimental evidence of territoriality comes from the studies by Altman and Haythorn (1967a) and Cowan and Strickland (1965) Altman and Haythorn noted greater territoriality among their isolated dyads than for control subjects It began with the claiming of fixed geographic areas and highly personal objects extending later to the more mobile less personal objects Cowan and Strickland found that their subjects staked out areas of exclusive or special use acting with hostility to trespasses by others

In a sense such instances of territoriality are manifestations of one s attempt to maintain some measure of privacy in difficult environments which largely thwart such a luxury Throughout the literature there are many cues about the importance to group members of privacy (see e g Farrell & Smith 1961 Levine 1965 Rasmussen & Wagner 1962 Weybrew 1963) but to date formal evidence is scant

Admiral Byrd (1938), in detailing why he felt it unwise to staff an advance base in the Antarctic with only two men, nicely summarized many points of the current discussion·

. it doesn't take two men long to find each other out And inevitably, this is what they do, whether they will it or not, if only because once the simple tasks of the day are finished there is little else to do but take each other's measure Not deliberately Not maliciously But the time comes when one has nothing left to reveal to the other, when even his unformed thoughts can be anticipated, his pet ideas become a meaningless drool and the way he blows out a pressure lamp or drops his boots on the floor or eats his food becomes a rasping annoyance And this could happen between the best of friends Men who have lived in the Canadian bush know well what happens to trappers paired off this way

Even at Little America I knew of bunkmates who quit speaking because each suspected the other of inching his gear into the other's allotted space, and I knew of one who could not eat unless he could find a place in the mess hall out of sight of the Fletcherist who solemnly chewed his food twenty eight times before swallowing In a polar camp little things like that have the power to drive even disciplined men to the edge of insanity During my first winter at Little America I walked for hours with a man who was on the verge of murder or suicide over imaginary persecutions by another man who had been his devoted friend For there is no escape anywhere You are hemmed in on every side by your own inadequacies and the crowding pressures of your associates The ones who survive with a measure of happiness are those who can live profoundly off their intellectual resources (pp 16–17)

Relationship with the Outside World The meaning of events outside the confines of the environment of isolated groups also is subject to profound change In some situations there is a loss in performance feedback and consensual validation from outside sources In cases where groups are cut off for lengthy periods, the usual meaningfulnesses and influences of society probably will diminish

One manifestation of frustrations within the confined group is that *much of the displayed aggression*, hostility, anger, and the like is directed at people and objects external to the group There are numerous examples of this in aerospace and other studies where the alleged "excessive demands" by outside personnel during tests are frequently resisted (see, e g , Agadzhanian, Bizin, Doronin, & Kuznetsov, 1963, Cowan & Strickland, 1965, Farrell & Smith, 1964, Hanna, 1962, McGrath, Maag, Hatcher, & Breyer, 1962, Rodgin & Hartman, 1966, Smith 1966) Although behind the sometimes angry resistance there are often reasonable complaints dealing with scheduling conflicts annoyance over outside control of activities, *poor support*, too much testing, and so on, it is likely that very useful scapegoating, of value to the confined group, is also occurring

Burns and Gifford (1961) conclude that the loss of information about outside events, about activities of others and the lack of important feedback from outside sources are important influences on the functioning of

isolated groups What meaning such deprivations might have for micro-societies, such as a space team on a lengthy voyage to another planet, can only be speculated at this time, but it is likely to be great

One interesting emphasis of the long term confinement study by Cowan and Strickland (1965) involved observations about the legal structure of the groups Greater resistance occurred during studies of the legal area dealing with ethical and moral behavior than for any other experimentation The subjects apparently gave little if any thought to the fact that they might need to know how to govern themselves in unusual situations, feeling instead that being able to select congenial and competent companions would solve the problem In general, the subjects resented the various rules involved in the study (many of which were for nutritional purposes) and systematically attempted to negate virtually all of them It was further found that they were unwilling to submit their own differences or grievances to adjudication and were inadept when forced by outside authority to do so

Reactions to Confinement

In this section typical reactions cited annoyances, symptomatology, and patterns of adaptation to confinement will be detailed

Boredom and Monotony Particularly in long term confinement experiences, typical descriptions by group members include reference to boredom and monotony Levine (1965), in an article summarizing recent submarine and Antarctic studies, comments that the boredom so often felt exists in spite of the fact that numerous facilities are available to alleviate such a condition Similar findings come from aerospace studies David (1963) summarized several experiments by Cramer and Flinn (1963), involving confinement of pairs of men during simulated flights The chief problem noted during these confinements some lasting 17 and some 30 days, was monotony Alluisi Chiles Hall and Hawkes (1963) reported the results of three highly motivated groups who endured confinement in a simulated space system crew-compartment These groups, one of six men confined for 15 days the others groups of five men, confined for 30 days apparently all suffered boredom This was particularly true after their task program had been learned well enough for it to become routine Writing about experiences on an Arctic expedition before the turn of the century, Brainard (1929) indicated that the monotony of the Arctic night was very difficult for his group to endure The men became melancholy sleepless, and very irritable And one by one they tried and dropped every diversion that any of the group members could think of

One investigator was a participant observer in a group of seven men working as a self-contained unit in the Antarctic (Smith, 1966) He reports that the group s reaction to monotony included widespread day dreaming to fill time and an intense desire for change even though the

change wasn't in the best interests of the mission. Boredom also appeared to be a sizable problem for two icebreaker ship crews on an expedition in the Antarctic, particularly when the ships became trapped in ice and usual activities ceased (McDonald, 1962).

Because so many of the likely future applications of small groups in isolated confinement will involve monitoring and other highly repetitive tasks, which may have to be performed where space and diversions are greatly limited, it would appear that boredom, caused by general lack of change, will long be a problem.

Motivation and Morale Changes. Unquestionably, the motivation and espirit of groups facing isolation will importantly affect their success. Nardini, Hermann, and Rasmussen (1962) report that, after extensive research on selection criteria for duty in the Antarctic, motivational considerations are still among the most important criteria. Actually of greater importance, *it seems, is to be certain to avoid selecting individuals displaying inappropriate motivations,* such as escaping marital conflict.

There are several reports of highly motivated small groups who appear to have endured confinement without apparent problems or ill effects. Examples are summarized by Chambers (1962). Adams and Chiles *(1960), in some of their earlier 96-hour studies, found no serious performance* decrements or motivational problems. Their later, longer studies of 15 days duration, however, revealed some reductions in effectiveness (Adams & Chiles, 1961).

Several other investigators have noted motivational decline throughout prolonged confinement, even among highly motivated group members (Agadzhanian, Bizin, Doronin, & Kuznetsov, 1963; Alluisi, Chiles, Hall, & Hawkes, 1963; Farrell & Smith, 1964; McGrath, Nhag, Hatcher, & Breyer, 1962; Reidy, 1953; Weybrew, 1961; Walkins, 1967). Although there are undoubtedly good reasons for some of these motivational drops, *such as poor leadership as reported by Reidy (1953),* conflicts between the confined group and outside agents, and so on, it is significant to note that no one has reported any instances of consistent rises in motivation or morale throughout lengthy confinement.

was assessed Personal motivation and group morale in general showed a declining trend after 10 days of confinement which continued largely throughout the voyage Concurrently, homesickness rose The height of morale appeared to be an inverse function of imposed regimentation, with morale being highest on Sundays when schedules were altered and more free time was allotted

Annoyances Some studies of confinement have attempted to obtain information about the sorts of things that have served as annoyances for group members Naturally, different physical environments will create vastly different problems Nevertheless the results presented here may be of some general utility In two fallout shelter habitability studies conducted at the Naval Medical Research Institute (Rasmussen & Wagner, 1962, Rasmussen, 1963) 100 man groups were confined for 2 weeks under crowded conditions The medically and psychiatrically screened volunteer Navy recruit subjects were not told how long they would be confined and were offered no special incentives As shown in Table 11–1, subjects were asked to rank order 21 potential sources of discomfort In general, the limited facilities for personal care, the monotonous diet, crowded conditions and behavior of others were the major annoyances noted This was so whether subjects were asked to perform the rankings according to "how much or 'how often the items had been annoying The first test was conducted during the winter, the second during the summer It is apparent that increased heat in the latter study led to more environmental annoyances and a shift in the position of sleep difficulties

The Boeing Company in Seattle conducted a manned environmental system assessment called Project MESA (Farrell & Smith, 1964, Page, Dagley, & Smith 1964) Although it was primarily a closed life support system checkout extensive psychological assessment was carried out before, during, and after the five man crew underwent 30 days of confinement The same list of discomfort sources was rank ordered as in the NMRI experiments The indications of how much these sources were annoying during the first 9 days as compared with the last week of confinement are also shown in Table 11–1 Toward the end of the 30-day confinement, behavior of others, the crowded conditions of the chamber, boredom and annoyances over food were among the most chosen discomforts The diet in the NMRI shelter study consisted of survival crackers and soup while in the Boeing assessment two NASA experimental diets were tried out Food is consistently noted as a highly important aspect of confined living probably because eating is one of the few pleasures available (Mullin & Connery, 1959) It is therefore not surprising that the diets used in the above and similar studies are not fully satisfying It is interesting to note that among the high status persons at Antarctic stations of the past are cooks who have done a particularly good job (Rohrer 1961)

TABLE 11-1 Rank Orders of Discomfort Sources for the NMRI Shelter Studies and the Boeing Company Project MESA Assessment

Source of Potential Discomfort	*Rank Order How Much It Annoyed*			
	Shelter Studies		Boeing Study	
	Winter	*Summer*	*Day 9*	*Day 30*
Lack of water for washing	1	1	2	8
Food	2	4	4	2
Dirt	4	3	14	10
Crowding of the shelter (Chamber)	3	5	10	4.5
Temperature and humidity	8	2	10	20
Behavior of others	5	8	3	1
Noise	7	-	1	6
Boredom	6	9	8	4.5
Odors	11	6	12	14
Lack of exercise	10	12	15	9
Bunks	12	10	20	16
Toilet facilities	9	15	5	-
Physical symptoms	14	11	18	12
Lack of privacy	13	16	6	13
Lights while sleeping	15	14	19	21
Sleeping difficulty	19	13	16	11
Inability to concentrate	17	17	10	18
Concern about the outside	18	18	17	3
Lack of organization	16	20	13	15
Lights while awake	21	19	21	19
Inadequate leadership	20	21	-	17

followed closely by complaints concerning adequacies of bathing and bathroom facilities odors lack of space, and food

Symptomatology Although there are considerably fewer instances of potentially problematic emotional symptomatology found in group-confinement studies than in studies of individual isolation, certain symptoms characteristically arise

Rarely have there been reports of illusions, vivid dreams, and the like Alluisi, Chiles Hall, and Hawkes (1963) indicated that some subjects in their long confinement studies had occasional vivid dreams but were not particularly concerned by these experiences Most of the reported symptomatology centers around sleeplessness depression, and general mood declines, compulsive behavior, psychosomatic problems, and, in some infrequent instances, more serious psychiatric problems

Considerable data have been gathered from personnel wintering over in the Antarctic, in order to understand better what such unusual duty is like and to provide valuable assistance in the selection of future personnel (e g , Gunderson & Nelson 1965a, Nelson, 1965, Shears & Gunderson, 1966) One phase of this work involved giving questionnaires to a number of wintering-over groups to provide information regarding the effects of group confinement upon affective states emotional symptoms, and somatic reactions The questionnaires were administered by each group s medical officer The first test was given prior to the onset of the Antarctic winter, the second some 3 to 4 months later in the middle of the winter, and the final test took place at the end of the winter period A summary of these test results is presented by Gunderson (1966b) Among the most prevalent symptoms reported in midwinter were problems with sleeping, including difficulty in falling asleep remaining asleep, and feeling tired during the day Depression and feelings of loneliness were also frequently reported, as were headaches, muscular soreness, feeling easily irritated or annoyed, and feeling critical of others All of these symptoms were reported to a greater extent during midwinter than before the start of winter

More recent wintering-over groups have been tested since various living-condition improvements have been made at the bases Although it would be reasonable to predict that emotional symptoms should have declined, because of the improvements, this was not borne out The percentages of men reporting various symptoms remained high, in fact, higher than for the previous studies

Gunderson concludes from these studies that emotional disturbances and symptomatic complaints tend to increase in healthy subjects exposed to the prolonged restricted stimulation of wintering over in the Antarctic

In general other reports highlight very similar findings Reports of difficulties in sleeping occur widely in the literature (see e g , Alluisi Chiles Hall & Hawkes 1963 Brainard 1929 Mullin 1960, Weybrew,

1961 Wilkins 1967) One area that has also received considerable attention is that of psychosomatic symptoms Because the members of most groups quickly learn not to alienate one another in the best interests of group maintenance it is reasonable that there are not more references to overt expressions of irritation and hostility It is also not surprising that so many nervous headaches and other psychosomatic complaints should be reported In nuclear submarine environments an individual s control of anger could be expected to be reasonably great Weybrew (1961) in summarizing the 83 day USS Triton voyage reported that an average of about 25 percent of the men on any given day had headaches of undetermined origin

Hammes (1964) writes that the most frequent medical complaints during his 14-day fall-out shelter studies were headaches and nausea These occurred most frequently around the 4 or 5-day period decreasing thereafter There was evidence that these were of largely psychosomatic origin This is based on the types of treatments to which the symptoms responded and on the fact that there was a rather remarkable decrease in medical complaints during the last 5 to 6 hours of confinement

That persons undergoing group confinement become depressed is another widely cited finding (Agadzhanian Bizin Doronin & Kuznetsov 1963 Brainard 1929 Cleveland Boyd Sheer & Reitman 1963 Gunderson & Nelson 1963 Hammes 1964 Nardini Hermann & Rasmussen 1962) Nardini and his co workers writing about observations of Antarctic personnel states that though the selection program has been generally successful acute emotional disturbances are not uncommon In addition to headaches low grade depressions are prevalent during the 3 month period of darkness Interestingly he reports that the typical military complaints of backaches and gastrointestinal problems are rarely found in wintering-over personnel Nardini concludes that many men may have experienced near psychotic episodes which may not have required treatment but which can create tense and stressful situations for the remainder of the station personnel

In studies where mood has been assessed during confinement general declines have been noted In the Boeing study (Farrell & Smith 1964) for example an adjective checklist was given at various points before and during the 30-day confinement After the eleventh day positive feelings significantly declined not to rise again until shortly before confinement was finished Cleveland Boyd Sheer and Reitman (1963) in their study of a family undergoing 14 days of fallout shelter confinement made use of adjective checklist and projective test techniques Their results also revealed mood changes indicating increased irritability and depression

There are few references to actual serious psychiatric episodes occurring in group confinement situations and these are probably well within expected percentages under normal circumstances even with selected

subjects Many lesser problems are obviously present as noted in the discussion of typical symptomatology Perhaps as problematic as any are compulsive acts The compulsive actions of group members often become matters of acute awareness and annoyance for the remainder of the group (see, e g , Byrd, 1938, Levine, 1965)

Rohrer (1961) has summarized from first hand impressions and from a literature review, what appear to be clear-cut stages of development of symptomatology during known length small group confinements He identifies three stages of adaptation The initial phase involves heightened anxiety which generally leads to an increase in physical activity The second phase is a long period of depression and adjustment to routine duty The third is a short period of affect expression just before leaving confinement, presumably because the repressive and social control forces operating earlier are lessened Although this may be a rather simplified picture it handles rather well a large amount of the research information about symptomatology

Performance Data

Several investigators have written about impairments in intellectual efficiency and performance declines during prolonged confinement (Burns & Kimura 1963, Eilbert & Glasser, 1959, Gunderson & Nelson, 1965a, Mullin, 1960, Rohrer, 1961) Mullin (1960) reports the results of a study in which a large number of men were interviewed near the end of their wintering-over period at some of the smaller, more isolated Antarctic stations Impairment of memory and difficulty in concentrating were stated by large numbers of the respondents in one instance, for example, about a third of the men at one station It was also observed that involvement in intellectual activity was low Many persons slated for such isolated duty indicate their intent to occupy themselves with intellectual pursuits, but little such activity is in evidence Perhaps as significant as anything is that members of such confined groups feel that they have suffered decrements whether or not they really have

Most such reports are based upon observations and upon retrospective appraisals by members of the groups themselves Several investigations have used intellectual and performance tests to measure potential decrements In none of these cases however have the durations matched the periods of confinement characteristic of duty in the Arctic and Antarctic

Intellectual Functioning In the fallout shelter study program reported by Hammes (1964) one interest was to assess any intellectual impairments that might result from the 2 week long confinement Tests of verbal reasoning numerical ability learning memory special perception and logical reasoning were given before and after confinement No evidence of any intellectual efficiency decrement was found

A recumbent control condition utilized by Zubek et al (1962) involved confining groups of five or six subjects in a room for a week A total of 40 subjects participated They were required to remain recumbent except for life sustaining activities Various forms of entertainment were available and they were free to converse with one another Several tests of intellectual functioning were administered before during and after confinement On only one the test of numerical reasoning were performances worse than those of a control group who lived away from the laboratory On the other nine tests such as verbal fluency digit span etc the two groups were not different

Hanna and Gaito (1960) also report the results of tests of intellectual functioning given during their study of a six man group confined for 7 days in a two-compartment chamber The tests of learning thinking and reasoning were given in alternate forms before and just prior to ending confinement Again no performance decrements were found

In the study by McGrath Maag Hatcher and Breyer (1962) a digit span memory task and an attention task showed learning effects with no decrements evident during the 5 day confinement During confinement however subjects showed a 10 to 15 percent decrement over the duration of an attention task session that was not present before or after confinement This finding may be accounted for by a motivational drop indicated by the authors

The study by Agadzhanian Bizin Doronin and Kuznetsov (1963) involved a much longer confinement of 60 days The two subjects were required to perform various mathematical computations linked with a conditioning procedure Although time needed to solve the problems appeared to decrease throughout the 60 days the average number of errors increased for both subjects In a similar length aerospace study (56 days) involving four men Rodgin and Hartman (1966) found no intellectual impairment that couldn t be accounted for by changes in task specific motivation

There is in summary very little evidence for serious shifts over time in intellectual functioning reported in the literature of short and medium term confinement The picture for long term confinement such as Antarctic stations is less clear So far no test evidence has been presented to confirm the decrements that so many persons feel really exist

Perceptual and Motor Skills Most of the performance data collected from small groups in isolation come from relatively short duration studies Although there is the assumption of poorer effectiveness for Antarctic wintering over parties there are no objective performance data available to date

Various studies of psychomotor performance have been conducted in the program of research on submarine habitability and selection (Wey

brew, 1963) In the study involving confinement for 60 days in a sealed submarine (Faucett & Newman, 1953), subjects were given a series of performance tests The measures were the Minnesota Manual Dexterity Test, two-hand tapping letter cancellation, and subtests of the Mac Quarrie Test for Mechanical Ability In general no systematic performance changes over time occurred There were some changes among test sessions, but they were mirrored by motivational changes which probably provide sufficient explanation of the rises and falls in performance

In the two-man 60-day confinement reported by Agadzhanian, Bizin, Doronin, and Kuznetsov (1963), some evidence is presented of increased time to perform the tracing of a geometric figure even though the accuracy of performance remained unchanged

During the Boeing five man 30-day confinement (Farrell & Smith, 1964, Page, Dagley, & Smith, 1961) tests of warning light monitoring, meter monitoring and of tracking performance were frequently given before and during confinement Significant learning occurred on all facets of these tasks Without the performances of control subjects for comparison the improved performances cannot easily be interpreted, but it is clear, at least, that confinement did not lead to decrements in either speed or accuracy of any performance The performance results presented by Alluisi, Chiles, Hall, and Hawkes (1963) similarly revealed no serious decrements for probability monitoring warning light monitoring, and auditory vigilance The same is true of performances which were sustained by a two-man crew during a 30-day systems test of a minuteman missile control center (Hartman et al, 1964) and by the four man crew during the 56-day confinement study conducted at the School of Aerospace Medicine (Rodgin & Hartman, 1966)

Adams and Chiles (1961), in contrast with the above studies report that in probability monitoring and vigilance tasks their confined subjects evidenced decremental performances over a 15-day *confinement* period Control subjects run later were superior to the confined subjects on these measures, hence, the authors conclude that the observed decrements during confinement were real

The two-man 10-day confinement study by Altman and Haythorn (1967b) included assessment of signal monitoring and two group tasks, a combat information center simulation requiring subjects to plot and report target locations and a decoding task in which subjects had to share information to achieve a solution to abstract reasoning problems Compared with the performance of control subjects the confined subjects, in general were poorer on the monitoring task but were superior on both of the group tasks Burns and Gifford (1961) found that where subjects had to operate routine tasks without apparent consequence, decrements occurred On more challenging tasks however, adequate performances were sustained

Consistent performance decrements have been found by Hicks (1962) in studies of 24 hour confinement in moving armored personnel carriers (APCs) The many environmental stressors added to the cramped conditions (e g , heat noise vibration, and fumes) make interpretation of the effects specifically caused by confinement difficult However, in one study involving 12 hours in a stationary vehicle, confinement under extremely cramped circumstances (and partly in high heat) produced similar losses in equilibrium, stamina, and locomotor and throwing abilities (Hicks, 1961)

One fast growing research area of considerable importance centers around man s entry into the sea A major prong of interest is multidisciplinary development of the capability for placing man on the bottom of the ocean at depths of up to 600 feet and sustaining his existence there for weeks at a time Pioneer efforts have been made by Cousteau (Cousteau, 1964, 1966) Link (Godley, 1963, Link 1963), and the U S Navy through its Project Sea Lab (Bowen, Anderson & Promisel, 1966, Helmreich, 1966, Radloff, 1966, 1967, personal communication)

In these projects men have lived for days (and sometimes weeks) in thin shelled abodes under hyperbaric conditions with the internal pressure roughly matching that of the chosen depth Once settled in their dwelling they could enter the water at will to carry out assignments, returning to the habitat for warmth meals, and sleep Under these circumstances decompression, caused by tissue saturation by gases, is required only at the end of the stay on the bottom The resultant is a higher percentage of diving work per unit time than is possible at such depths by any other current method

Conshelf 3, the designation for a recent test headed by Cousteau (Cousteau 1966) involved six oceanauts living for 3 weeks at a depth of 328 feet Physiological and psychological testing was carried out as a part of the project Although Cousteau reports no hard data, he indicates that no deterioration in reflexes, coordination, and physical well being were found

The most recent Navy Sea Lab study (SEA LAB II) involved 28 divers living at a depth of 205 feet in groups of ten men at a time (Bowen, Anderson & Promisel, 1966, Helmreich 1966, Radloff, 1966, 1967, personal communication) Twenty six of the men remained for 15 days, while two men spent 30 days Closed-circuit television observations were made and a large array of psychological tests and measures of activities were employed Generally, the groups functioned effectively, although as will be detailed later, there were sizable individual crew member differences in reaction to the experience and these were related to adequacy of performance

The concepts of isolation and confinement relate in some measure to America s manned space-flight program (Fraser, 1966) A recent article

(Anonymous, 1967) referred to a summary by Berry of the medical and psychological results of flights to date. He indicates that no unusual psychological phenomena or performance decrements have been observed; but hastens to add that missions so far, the longest of which has lasted 14 days, could hardly be characterized by terms such as social isolation and monotony.

In the area of measured performances, then, persons undergoing group confinement generally seem to be able to maintain their abilities, although there are some reported instances of skill decrements (perhaps mainly when cramping is severe). The lack of control-group data for most of these studies, coupled with their relatively short confinement durations, seriously limit useful generalizations.

It would be well to mention that such experiences as man-in-the-sea and space flight are greatly different from many of the other studies dealt with in this chapter. Many more stressors are usually present in the former more glamorous sorts of missions and participants achieve greater rewards from involvement as a rule. The results of such experiences may not be quite as favorable when longer mission durations are involved and when participation is more commonplace and routinized. However, the ratings of long-term performance that are available from stations in the Arctic and Antarctic, would suggest that when individuals are sufficiently motivated to perform a given task their skills are likely to be found generally acceptable.

Physiological and Biochemical Changes

With the advent of manned space flight and man-in-the-sea programs there has been a surge of interest in the study of potential physiological and biochemical changes in man undergoing lengthy confinement in a variety of crowded and otherwise austere environments (Adams & Chiles, 1961; Agadzhanian, Bizin, Doronin, & Kuznetsov, 1963; Alluisi, Chiles, Hall, & Hawkes, 1963; Johnson & Long, 1966; Speckmann, Smith, Offner, & Day, 1955). A recent report (Fraser, 1966) contains excellent coverage of such data from aerospace and other confinement studies. Zubek, in chapter 8 of this book, details physiological and biochemical findings centering mostly on studies of individuals in sensory and perceptual deprivation. Because of the availability of these two comprehensive sources, few details appear to be warranted here.

Some overview observations may prove helpful in dealing with the diverse data to be found. The physiological and biochemical status of an individual, alone or as a member of a group, is presumably subject to environmental and psychological influences in both types of confinement. However, there are two major areas where important differences are likely to arise. In the case of psychological stressors, the individual confined as a part of a group faces potentially difficult interpersonal conflicts while the individual isolated alone contends with problems of a more personal and

perceptual nature The result is probably similar biochemical indices of irresolved conflict and tension even though caused by perhaps rather different factors Another comparative consideration deals with the sorts of environmental stressors present in a given situation It is often characteristic of simulated spacecraft environments actual space flight deep ocean operations, etc to have many causal loci for physiological status in addition to confinement or isolation *per se* Hence persons participating frequently face hypobaric or hyperbaric pressures gaseous environments that differ from sea level mixtures presence of greater numbers and levels of trace contaminents simulated or real weightlessness potentially great physical dangers and so on On the other hand studies of isolated individuals characteristically deal with a one atmosphere environment good ventilation comfortable temperature and so on In group confinement, then physical factors may play a potentially greater role than they would in usual studies of isolated individuals

One common denominator often found when physiological changes are reported is close confinement Persons who are not free to exercise or move around to any great extent appear to be more subject to physiological problems in both study categories A second denominator potentially common to individual and group isolation is monotony Especially when durations are prolonged a response picture that seems to emerge in the face of the compounding boredom is a lowered physiological state of arousal

Individual Differences and Selection

Just as is the case for solitary isolation various individuals adapt differentially to group confinement Virtually all group-confinement assignments are voluntary Hence considerable implicit selection takes place before groups are constituted For instance it can be assumed that persons with obviously detrimental traits such as claustrophobia will rarely volunteer It is true however that persons are not always likely to be able to sense their personal traits that might lead to maladaptive responses to group confinement Additionally accidental factors of group composition may militate against group effectiveness For these reasons several investigators have been expending considerable effort to determine important aspects of individual differences in adaptation to group confinement and to establish useful selection criteria

One research effort recently summarized by Gunderson (1966a 1966b) has dealt with adaptation to the extreme environment of the Antarctic Some of the factors that appear to be highly related to successful performance are the work motivation emotional stability and social compatibility or likeability of the station members

Recent additional analyses of Antarctic experiences have been made using a refined inventory technique (Shears & Gunderson 1966) Three factors—social compatibility personal motivation and group accomplish

ment—were shown to be stable over time and to be related to adequacy of adaptation

In general biographical data have not been consistent predictors of Antarctic adaptation success Factors such as adequacy of adjustment to prior duty situations and having a low prior delinquency truancy index appear to be generally useful But the utility of other factors is seemingly dependent upon the size of station and probably many other conditions that are not static (Gunderson & Nelson 1965a)

The extent of coping with past difficulties was found by Hammes (1965) to relate to fallout shelter endurance Those who had faced more family problems in recent years (e g death of family member divorce medical operation etc) were better at enduring confinement

Eilbert and Glasser (1959) studied the differences between well and poorly adjusted USAF enlisted personnel serving at isolated Arctic bases The selection of these two groups was based upon the ratings of immediate supervisors The members of the well adjusted group tended to describe themselves as conscientious and responsible individuals who accept rather than reject authority The poorly adjusted group described themselves in other less consistent terms However compared with the well adjusted group they were found to be more complaining and more fearful of the Arctic to go to sick call more often to have greater interpersonal problems and to be no more than marginally concerned about their work These authors also conclude that evidence of prior adequate adjustment augurs well for later assignment to isolated duty stations

Wright Sisler and Chylinski (1963) conducted an investigation of personality characteristics associated with favorable adjustment to northern isolated living The data were contributed by 197 civilian electronic technicians many of whom staffed outlying Doppler sites in groups of from two to eight men Based on supervisor ratings a top and a bottom adjustment group were selected after completion of a 1 year tour Various tests including the MMPI and the EPPS were given to the men prior to beginning their northern duty As measured by the EPPS the poorly adjusted group showed greater aggression and lesser deference and orderliness than did the well adjusted men The poorly adjusted subjects were higher on five MMPI scales Hypochondriasis (Hs) Psychopathic Deviate (Pd) Psychasthenia (Pt) Schizophrenia (Sc) and Hypomania (Ma) In general the findings indicate that persons given to antisocial and psychotic tendencies are poor risks for efficient functioning in conditions of isolation

The screening criteria for selection of Antarctic personnel were summarized by Nardini Hermann and Rasmussen (1962) As of 1962 there were five primary factors Viewed to be particularly important is past personal effectiveness with a major emphasis being the candidate s technical competence High appropriately directed motivation is desired

Ratings are made of a candidate's ego strength and emphasis is placed on the adequacy of his defense mechanisms. Attempts are made to detect personality problems that might be a demoralizing influence or a source of friction. A final emphasis is to evaluate the individual in terms of the group to which he would belong.

Very similar selection criteria for the submarine service were indicated by Weybrew (1961). The candidate must (1) be a volunteer, (2) meet aptitude criteria in the areas of verbal and arithmetical comprehension and mechanical ability, (3) display high motivation, (4) possess emotional stability, and (5) display appropriate autonomic nervous system reactivity and resiliency.

The importance of attending to the composition of the group is highlighted by the Altman and Haythorn study (Haythorn & Altman, 1967b) in which the *a priori* incompatible dyads adapted less adequately to confinement than did those constituted to be compatible. Hence awareness of aspects of the group to which a person will be assigned clearly must be considered as carefully as individual selection criteria.

In the SEA LAB II study (Bowen, Anderson, & Promisel, 1966; Helmreich, 1966; Radloff, 1966, 1967, personal communication) the effects on performance of various individual difference factors were assessed. The greater the self-reported fear and arousal (using adjective checklists), the fewer the number and shorter the duration of diving missions away from the habitat. First-born and only children were found to be more fearful while in the experimental conditions and also displayed poorer diving mission performance. Also, failure of an individual to share in group activities and social behavior was associated with higher levels of reported stress and inferior performance. Similarly, those who were the greatest users of the telephone for personal communications to outside persons indicated higher fear and arousal and spent less time diving.

Variables Affecting the Success of Groups in Confinement

Several variables appear to affect the adequacy with which groups adjust to their confinement experience. Some important variables, such as personality, motivation, and compatibility of group members, have been discussed earlier. Although the factors mentioned below have in most cases received relatively little systematic attention in group-confinement studies, the fractional results are sufficiently suggestive to warrant comment.

Group maintenance activities appear to be particularly important. Brainard (1929) and Byrd (1930, 1938) repeatedly refer to efforts to maintain espirit and to keep the group functioning effectively. Firm but fair discipline coupled with trust and respect of the group's leadership seems to have been particularly important in the incredible story reported by Brainard of survival against nearly impossible odds. Successful leadership

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efforts are also obvious in such areas as peace keeping and guaranteeing the rights of individual group members Torrance (1957a, 1957b) reports data on many isolated groups undergoing survival training exercises Often such groups, particularly those with less than six members, fail to recognize the need for leadership Such leaderless groups when under stress, may be subject to serious disruptions, including emergence of "survival of the fittest" behavior with its consequent shattering of group effectiveness In view of these implications there seems to be little reason to argue with Boag (1952), in reference to confinement, when he strongly recommends emphasis on efficient small group organization and leadership, clear definition of objectives and methods, adequate training and requisite skills and efforts to maintain morale and discipline

All other things being equal, probably the more severe the isolation and confinement conditions the more difficulty the group is likely to experience Miller (1952a 1952b) reporting on human relations at isolated aircraft control and warning (A C & W) sites stated that more morale and personality problems were found at the smaller, more isolated sites than for larger stations This result apparently ties in with the finding reported by Nardini Hermann, and Rasmussen (1962) that fewer emotional and interpersonal problems were found at the larger Antarctic stations than at stations comprised of 15 to 40 men

Two aspects of work rest cycles emerge as important One deals with the separation of personnel because of different schedules hence serving as a useful reducer of interpersonal contacts Persons undergoing confinement, where 24 hour a-day schedules are involved, frequently report that this enforced separation helped them to remain on better terms with other group members (see, e g, Farrell & Smith 1964) On the other hand, certain work rest cycle schedules may serve to increase the difficulty experienced by the confined group For example, Adams and Chiles (1960) reported that subjects following an 8-hour-on eight hour-off duty cycle found it less satisfactory than did subjects experiencing 2 and 2, or 4 and-4 hour work rest cycles In the earlier case, a full 48 hours would be required to bring a man back to the next full cycle Hence, he would be constantly trying to adjust to sleeping or working during hours of a given day which had been occupied by the opposite activity the previous day Being thus disoriented with respect to a usual diurnal cycle could easily lead to problems of irritability and inefficiency Bloom (1962) reveals a similar problem when the rotating of various shifts among personnel is tried The system of rotating shifts which at first glance is so eminently fair, may impose a physiological and psychological hardship on the personnel every time shifts are changed and may lead to decreases in efficiency and vigilance Obviously, the carrying of such penalties into a confinement situation would be likely to lead to further difficulties

Careful consideration given to the design of the habitat and equipment is also likely to be important to the success of small groups during confinement In the Boeing study (Farrell & Smith, 1964), considerable annoyance appeared to be generated by some difficult to use equipment For example, the water pump used for reconstituting food required resetting under pressure prior to being able to draw water Much of the annoyance seemed to be directed toward certain subjects who failed to reset the pump after obtaining water, thus leaving the work for the next user Had the pump been so constructed that the user had to exert the force during the actual stroke that obtained water (or if the crew had all agreed not to reset the pump after drawing water) probably this piece of equipment would not have been a source of interpersonal friction Other considerations which appear to help groups to get along better are designs that take into account the privacy needs of group members and permit adequate sleeping conditions while other persons are active and methods that keep noise and odor levels low In general, it appears that those design and planning features that reduce unnecessary interpersonal contacts and interdependencies (e g simplification of meal preparation and cleanup) are likely to improve the plight of the typical group in confinement

Obviously many other factors are likely to improve or degrade chances for successful endurance of confinement experiences Unfortunately, however, it has been the nature of most research to date not to have included systematic comparative checks of such variables At the Naval Medical Research Institute, data collection has recently been completed on a study of confined dyads designed to assess the importance of three variables assumed to bear on confinement tolerance (Altman, Taylor, & Wheeler, 1967, personal communication) The independent variables were privacy afforded the individual crew members, cultural awareness, defined as the extent of audio contact from the outside world permitted during confinement, and expectation as to duration of confinement Some groups expected a duration of 4 days others 20, but confinement was always set to last 8 days Information from this study, involving confinement of 35 pairs of men should be an important addition to the literature

FUTURE RESEARCH

There are many practical applications of small groups in isolated confinement that have influenced psychological research conducted to date and that will doubtless continue to have a profound influence on the direction of future investigations Major impetus in the past has come from Arctic and Antarctic expeditions and more recently from the many Antarctic stations inhabited by several nations and used for a wide variety

of multidisciplinary research purposes Protection of the upper perimeter of the North American Continent led to the establishment of DEW line surveillance outposts requiring full time manning Since 1957 a number of drifting stations have been set up on ice floes in the Arctic Ocean Teams of scientists living atop these floating ice islands, have had to endure difficult isolation while conducting a full spectrum of research on the Arctic environment, from sea floor mud to outermost atmosphere (Thomas 1965) A large amount of psychological research, particularly on the selection of men for difficult duty, has come from the submarine service Radar picket ships Texas towers, lighthouse ships and other remote Coast Guard installations are similar applications obviously deserving attention The potential need to understand fallout shelter living has promoted various behavioral study efforts, and interest has been engendered on behalf of special mission groups, such as Strategic Air Command (SAC) bomber crews long range patrols and Special Forces units, who often must operate under difficult, sometimes remote circum stances Even the recent U.S expedition to climb Mount Everest included behavioral observations and evaluations (Emerson, 1966, Lester, 1965)

Two of the most fascinating research frontiers of all involve man's entry into the far reaches of outer space and the depths of the sea The day of manned orbiting laboratories circling the earth repeatedly for months on end and distant space voyages taking more than a year is nearly here It is no doubt clear that crew requirements for these sorts of missions (involving greater isolation and monotony) may markedly differ from those of current space activities The ocean's frontier is equally fascinating and holds great promise of yielding to the world sizable food and mineral resources A considerable man in the sea research effort has begun, aimed at wide utilization and scientific study of the continental shelf and the ocean s depth Progress is rapidly being made toward plac ing effective working teams of divers on the continental shelf Cousteau's last study (1966) successfully employed a depth of 328 feet The Navy s next SEA LAB project is planned for a depth of greater than 400 feet And, keeping pace, more and more sophisticated deep-operating vehicles and habitats are continually being designed

In short, man has found ever increasing occasions that have required isolated confinement away from his parent society

The experience of being in isolated confinement has been difficult for enough small groups in enough different settings so that there can be little doubt that this is an experience deserving concerted additional study Drawing from past research and from conditions likely to be faced in many of the above practical applications of small groups in confine ment, Table 11-2 contains examples of classes of variables that are either known to or potentially might affect the physical safety physiological and emotional well being social behavior and various performance capa

and other severities. Because many of the most problematic future applications, some of which were discussed above, probably will involve designs where crew accommodations will be cramped at best, one major behavioral research goal should be the study of relatively small groups required to occupy seriously crowded facilities for long mission durations. A range in group size from two to six persons probably will encompass the needs of most of these missions. Already it is known, for instance, that two-man groups frequently run into trouble. Yet, very little systematic confinement research information is available relating to the performances of groups comprised of three to six members. In partial response to these study needs, plans for the next experiment on small groups in confinement at the Naval Medical Research Institute tentatively include varying crowdedness, group size (probably comparing two- and three-man groups), compatibility, and extent of training to resist deleterious effects of confinement.

In addition to other experiments focusing on different group sizes, studies of group-maintenance functions and of environmental structuring appear to be important. Looking first at the broad area of functions to maintain group effectiveness, there are several important unanswered questions such as: How should the group handle disruptive behaviors like irritability, hostility, and aggression? Are there aspects of group process and structure that are more or less amenable to compatibility? What leadership styles are most effective? What compositions of similar or different ranks, ages, and so on, are the most suitable for group confinement?

Research on environmental structuring in confinement is very much needed. The environment of a given confinement situation should be carefully evaluated to determine the best means for ensuring privacy of the group members, to simplify facilities to reduce interdependence of group members, and to design equipment to remove unnecessary sources of annoyance. One of the more difficult questions deals with the relationship between meaningfulness of the crew member's tasks and extent of automation of equipment and systems. Letting the crew members perform interesting tasks as a means to defeat some portion of the monotony of long missions may be a wiser choice than trying to rely on more full-scale automation.

There are still several questions that should be addressed, relating to potential performance decrements under lengthy confinement circumstances. Although relatively few indices are currently available, there is the implication that very long confinement (sometimes including exposure to exotic environmental conditions) may lead to important physiological changes that may have intellectual efficiency and performance change concomitants. Drugs might play a part in keeping individuals in states conducive to effective performance. The difficult area of selection still

leaves many unanswered questions Future research clearly must focus on group specific factors as well as the individual selection factors which are more conventionally applied

A final area of interest is that of the relationship of the isolated group to the outside world Particularly relating to distant space voyages there is a fascinating array of questions dealing with the extent to which family units should crew such remote missions how much contact with the outside world there must be how to maintain relevant performance feedback to the isolated group how the group maintains the ability to relate its thoughts feelings and activities to the intellectual and emotional pulse of the distant world how legal and microsocietal issues are to be resolved and what problems of readjustment to society will occur for returnees

The answers to these and similar questions will importantly bear on the success of many a future small group operation that involves as one of its constituents profound isolated confinement To the extent that individuals tend to withdraw from one another and that general boredom and monotony characterize lengthy group confinement over time there are probably more similarities between the experiences of confined groups and individuals than would be obvious at first glance Hence answers should be sought from laboratory and field studies of both Large contributions need to be made by researchers stressing classic experimental clinical social human engineering physiological and biochemical orientations

SUMMARY

It has been the purpose of this chapter to survey studies and accounts of small groups in confinement There are many current instances of isolated confined teams often operating far from their parent society for long periods of time Examples are groups wintering over in the Antarctic those manning the DEW line lengthy nuclear submarine operations and now man in space and man in the sea Considerable field and laboratory research has been generated by these and other applications and due to the influence of sensory and perceptual deprivation research The available information about small group confinement is heavily anecdotal with research studies frequently lacking important aspects of scientific rigor Nevertheless useful generalizations appear warranted

It is usually assumed that fewer problems exist for small groups in confinement than is so for individuals Other persons seem to enrich the environment making it more tolerable In contrast with findings from studies of individuals isolated alone groups in confinement report far fewer unusual sensory experiences perceptual distortions unusual dreams

and so on. Confined groups, however, often face very difficult interpersonal problems and, particularly in length confinement, may experience tedious boredom due to the unchanging environment. Hence, group confinement, too, has its problematic aspects.

As well documented as any finding in the group-confinement literature is sizable presence of irritability, hostility, and personality conflicts, although often, to avoid alienation of the group, persons make great efforts toward self-control. These interpersonal problems have been shown to be more serious among groups, who, by personality composition, could be expected to be incompatible. Highlighting the importance of group compatibility for confinement, incompatible groups also are under more stress and report more symptomatology than do compatible groupings. Members of confined groups tend to withdraw from one another and from group activities more and more as lengthy confinement drags on. They also display increased territoriality for areas and for possessions, perhaps in their quest for privacy.

Relationships with those outside of confinement are subject to change as well. Much of the aggressive hostility that is observed is frequently directed away from the group, perhaps representing useful scapegoating. There is speculation that the loss of meaningful and relevant feedback from the parent society may be a problem, particularly in very lengthy and isolated confinement.

There are several reactions to group confinement that are frequently stated. In lengthy confinement, boredom and monotony are characteristically mentioned even when facilities are available to alleviate the problem. For some groups morale and general motivation remain at acceptable levels, but pronounced declines are frequently in evidence and there are no reported instances of consistent morale increases over time.

Many things serve to annoy members of confined groups. These annoyances frequently center around crowded conditions, interpersonal problems, food, difficulties in maintaining cleanliness, and environmental factors such as noise and odors.

Most of the reported symptomatology focuses on sleeplessness, depression, general mood declines, compulsive behavior and psychosomatic problems. It appears as if holding back overt expression of irritation and hostility leads to frequent instances of headaches and other psychosomatic complaints.

Performance measures have been employed in many studies. As a rule, neither intellectual effectiveness nor perceptual-motor ability shows any consistent change of note during short-term confinement. The picture is not so clear for very lengthy durations, such as is characteristic of wintering over in the Antarctic. Impairment of memory, difficulty in concentrating, low energy for intellectual pursuits, and less team-performance

effectiveness are often reported So far, test data are lacking to substantiate many of these feelings

The physiological state of the group member undergoing confinement is often subject to many influences in addition to confinement such as exotic gases to breathe, hyperbaric pressure, etc When confinement is so crowded that movement is limited, potentially debilitating changes are noted In many other studies however, no particular physiological changes of consequence are detected However, there does appear to be the potential for lowered arousal states among groups in confinement that has been found in individual isolation studies

There are wide individual differences among members of a group and among groups in terms of confinement tolerance Some important factors appear to be work motivation, social compatibility, emotional stability, prior job success, and prior emotional and social adjustment Future selections for participation in group confinement clearly must include group considerations in addition to the more conventional individual criteria

There are also a variety of individual, group, environmental, and miscellaneous situational factors affecting the success of confined groups These are shown in Table 11-2 of the text Within a particular confinement situation, such factors as leadership and other group maintenance functions are important, as are human factor considerations of the environment to provide privacy, reduce unnecessary annoyances and so on

It can be concluded that the experience of being in isolated confinement has been difficult for many sorts of small groups in a wide variety of different settings As such isolated confinement constitutes a problem of potentially serious proportions for many current and projected practical applications of small group operations Many suggestions for additional necessary research are offered Particular attention to unheralded, lengthy, monotonous missions, requiring crowded small area vehicles or abodes is strongly recommended

III

Theory

12

Theoretical Formulations: I

Marvin Zuckerman

A symposium held at the American Psychological Association annual convention in 1959 was called "Sensory deprivation: facts in search of a theory." The last chapter of Vernon's (1963) book on sensory deprivation (SD) is entitled "Facts without a Theory." Zuckerman and Cohen (1964a) after reviewing some of the theories of SD stated: "As yet the theoretical issues are not drawn so sharply that we could pose one theory against another. Hopefully the next decade of work on perceptual isolation will witness more precise defintion of the theories and experiments more precisely aimed at the theoretical issues" (p. 18). A comparison of the state of the field in 1959 with the present reveals that facts have increased geometrically while theories have remained static. Although some studies have implications relevant for one or another of the theories, few are constructed to test the relative value of the theories in prediction of the data. SD research is still more inductive than deductive, and much time that is being wasted chasing irrelevancies could be better spent on the track of bigger theoretical game.

Theories of SD may be grouped into several broad classifications: (1) physiological, with particular emphasis on the reciprocal relationships among receptors, reticular formation, and cortex; (2) personality, particularly psychoanalytic, body field orientation, introversion-extraversion, and optimal stimulation level approaches; (3) drive or need, with postulation of a specific drive for varied stimulation, exploration, or information; (4) social influence, with emphasis on set, expectation, and demand characteristics of the SD situation; and (5) cognitive or perceptual theories. Social influence and cognitive theories are discussed in the following chapter by Suedfeld.

Theories will be discussed with some attempt to examine the relevant evidence relating to their validity. Most of these theories are not contradictory but represent different levels or modes of interpretation. Many are psychophysiological theories, their models using both behavioral and physiological terms.

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GENERAL THEORETICAL BACKGROUND

The concept of activation or arousal [1] is central to most physiological theories of SD. This concept has increasingly been used in place of the Hullian concept "Drive." Hull (1943) tied Drive to an increase in intensity of a Drive Stimulus. The Drive Stimulus was an interoceptive one related to recurrent and fundamental physiological needs, especially hunger, thirst, and sex, or to painful stimulation from external sources. The general Drive level consisted of some kind of summation of all drives present at some particular time. Other motives were accounted for by secondary or acquired drives, or neutral stimuli associated with primary drive stimuli. Drives created states of activation in which responses were made until a particular response led to reduction of the drive. The drive-reducing response would be "reinforced" by the drive reduction and become more prepotent in the "habit-family hierarchy."

The concepts of Drive and Reinforcement ran into strong opposition, not only because they did not adequately describe the motivation in the delimited areas, but also because they were inadequate in describing a broader range of animal and human behavior. One obvious fact is that both animals and humans engage in a great amount of behavior, unrelated to primary reinforcement, which increases stimulation rather than reduces it. One response of Drive theory has been to add "Exploratory" drive to the basic list, ignoring the problem of the underlying physiological need or the characteristics of the stimulus associated with this drive.

The theory of Donald O. Hebb (1949; 1955) took a much broader view of motivation. Citing neurophysiological evidence that the nervous system is in constant activity, and not passively waiting for arousal by stimuli, Hebb said that the activity of the brain itself constitutes the "drive" of behavior. The motor is always running whether one is in neutral gear or drive. Harlow (1953) has cited many observations of self-actualizing monkeys, working on problems unconnected with food or pain-escape rewards, to ridicule the visceral drive reduction conceptions of motivation. "Learning for its own sake" was not invented by man, curiosity is not confined to our species, and play is not a human prerogative. As Harlow points out, food deprivation creates states of arousal which may actually be inimical to performance of any degree of complexity greater than bar pressing or running down a simple maze pathway. However, Harlow places the motivating force in the external stimulus which functions as a releaser of innate behavioral propensities. Hebb (1955), on the other hand, points to the arousal system within the primi-

[1] The terms activation and arousal tend to be used synonymously in the literature.

tive brain stem, the reticular formation. Through this system all sensory excitations reach the cortex to create levels of activation necessary for effective cognition and learning. Stimulation from any source has two functions: a cue function guiding behavior, and an "arousal or vigilance function." "Without a foundation of arousal, the cue function cannot exist" (Hebb, 1955, p. 349). The postulated relation between the level of cue function (effectiveness of discrimination and learning) and the arousal function are shown in Figure 12–1 from Hebb (1955). This is a descendant of the old Yerkes-Dodson Law (1908) relating drive (stimulus intensity) to rapidity of habit formation. Spence (1958) has presented a new version of this law translated into modern Drive theory: High Drive (in humans, defined as emotional tendencies reported in a questionnaire) facilitates learning where one response is dominant but inhibits learning where competing responses are present, because high Drive energizes all of the competing responses. Spence has also used physiological measures to define "emotionally" based Drive.

The concept of activation has been elaborated and related to psychophysiological indices of emotions by Duffy (1957; 1962), Malmo (1957; 1959) and Schlosberg (1954). Duffy defined the level of activation as "the extent of release of potential energy, stored in the tissues of the organism, as this is shown in activity and response" (1962, p. 17). The activation continuum extends from deep sleep to states of high excitement. Others

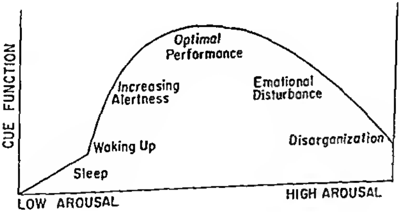

FIGURE 12–1. *Postulated relationship between "arousal function" and "cue function."*

SOURCE: Reprinted by permission from D. O. Hebb, *Psychol. Rev.*, 1955, 62, 243–254.

would prefer to define the concept in terms of arousal occurring without gross muscular adjustments

Activation may be defined in terms of a variety of physiological indices including cardiovascular temperature and respiratory measures but Duffy feels that EEG GSR and EMG are the best measures of the construct Activation is not a specific drive which acts selectively on specific S R units it constitutes the intensity dimension for all emotional states (Schlosberg 1954) Both Malmo (1959) and Schlosberg like Hebb postulate an inverted U shaped function to describe the relation between activation and behavioral efficiency However Schlosberg notes that there may be an optimal level of activation for each individual as well as for each task Duffy (1957) also comments on individual differences In the same stimulus situation there are differences between individuals in the degree of arousal These differences tend to persist and thus to characterize the individual (p 273) These differences in arousal are considered to be more molar than individual differences in response of any one physiological system cortex muscle or skin The individual differences in arousal may find expression in more complex behavioral organization i e personality traits

The homeostatic concept of an optimal level of stimulation or arousal has been offered by many as a substitute for the drive reduction basis of motivation Hebb and Thompson (1954) stated that organisms act so as to produce an optimal level of excitation Schneirla (1959) suggested that through evolutionary selection animals have acquired mechanisms which cause approach to sources of moderate stimulation and withdrawal from sources of intense stimulation Leuba (1955 1962) stated that when overall stimulation is low reactions which increase stimulation are learned but when overall stimulation is high reactions which decrease stimulation are more readily learned In other words responses which tend to maintain an optimal level of stimulation are prepotent Berlyne (1960) has stated the hypothesis in terms of arousal for an individual organism at a particular time there will be an *optimal influx* of *arousal potential* Arousal potential that deviates in either an upward or a downward direction from this optimum will be drive inducing or aversive The organism will strive to keep arousal potential near its optimum which will normally be some distance from both the upper and lower extreme (1960 p 194) McClelland Atkinson Clark and Lowell (1953) and Young (1959) have stated similar theories in hedonic terms Small discrepancies from an adaptation level of stimulation produce pleasant affect large ones produce unpleasantness Pfaffmann (1960) has shown how such a concept describes affective reactions to various gustatory intensities Moderate stimulus concentrations of sour salt bitter tend to be rated as pleasant up to some optimal concentration thereafter ratings

shift more toward the unpleasant with increasing concentration of solution

PHYSIOLOGICAL THEORIES OF SD

Lindsley (1957, 1961) more than any other theorist, has centered his theory around the reticular activating system (RAS) of the brain stem Until recently neurophysiology had defined only the specific sensory pathways to the thalamus and cortex Through the work of Moruzzi and Magoun (1949) the existence of a nonspecific sensory system receiving collateral fibers from the primary sensory pathways has been discovered Electrical stimulation of the reticular area changed the cortical activity from slow, high voltage sleep patterns to low amplitude desynchronized fast activity or activation Later studies showed that surgical interruption of the ascending reticular activating system (ARAS) eliminated the waking activity of the EEG and produced a somnolent animal Interruption of the specific sensory pathways does not produce this effect Other research has shown that the ARAS is itself activated by peripheral stimulation of somatic visual auditory and visceral systems Thus sensory stimulation ultimately may control cortical activation or alertness through its regulation of activation of the ARAS Relative absence of peripheral stimulation and with bodily needs generally satisfied tends to lead to quiescence behavior and eventually to sleep (Lindsley 1957 p 66) However, the RAS is not only controlled by sensory stimulation from below but has been shown to respond to cortical stimulation from above Thus the RAS may be activated by cognition as well as by sensation Conceivably the system may also be deactivated by central inhibitory areas

If incoming sensory stimuli keep raising the activation level of the RAS and the cortex a positive feedback situation might be created which could disorganize the brain Feedback control systems extend downward from the cortex through the reticular formation to the first synaptic level of sensory pathways These control systems can raise or lower the intensity of incoming stimulation An alternate system of feedback control exists in the thalamocortical system This system also contains specific and nonspecific nuclei In deep anesthesia the ARAS and its electrocortical activating role are blocked but sensory messages are still transmitted along the specific projection nuclei of the thalamus eliciting evoked potentials but no apparent behavioral or conscious response Lindsley identifies the ARAS with a general alerting function (arousal) and the thalamocortical projection system with specific alerting or focused attentiveness A review of studies of reticular mechanisms and behavior can be found in Samuels (1959)

Zuckerman (1964c) has suggested that Lindsley's theory is correct, but does not account for intraspecies or interindividual differences in human responses to sensory deprivation. Whether due to constitution or experience there are marked individual differences in the setting of the homeostat. He has also suggested that individual differences in stimulation need may determine whether physiological arousal or depression is the response to sensory deprivation.

Schultz (1965) has also postulated a homeostatic mechanism which he calls sensoristasis. Sensoristasis is defined as "drive of cortical arousal which impels the organism (in a waking state) to strive to maintain an optimal level of sensory variation . . . a balance in stimulus variation to the cortex mediated by the ARAS (ascending reticular activation system)" (p 30).

The alpha rhythm of the brain is characteristic of a waking relaxed synchronized firing of brain cells. Visual stimulation, attention demands or problem solving change the EEG pattern to one of desynchronized low amplitude fast activity. Lindsley speculates that this desynchronization is due to independent operation of smaller aggregates of brain cells. He notes that Hebb's concept is one of differentiation at the neural level. Differentiation is a concept frequently used at the behavioral level to explain perception or habit formation.

Lindsley (1961) says: "If one conceives of the reticular formation as a kind of barometer for both input and output relations, then it is a short step to the assumption that it has an adaptation level. Psychologically this should be reflected in a suitably high or low level of attention or anticipatory set. However, with exceptional conditions of sensory deprivation literally a void would be created with vigorous striving for necessary stimulation to keep the ARAS and, in turn, the cortex, going on an activated basis so that one's past or present may be reviewed. Without such stimulation boredom, inactivity, and ultimately sleep prevail" (p 176). From Lindsley's conception one would deduce that the initial reaction to sensory deprivation would be arousal ("vigorous striving") followed by depression and a resetting of the "barometer" at some lower level of adaptation. Because either overstimulation or understimulation may disrupt the RAS either condition may disrupt cortical functioning.

Hebb (1955), Lindsley (1961) and others have used a homeostatic model which seems to make the assumption that states of low arousal short of sleep are aversive. But as Berlyne (1960) points out, these states of low stimulation and arousal are usually quite agreeable if one is tired or sleepy. They are disagreeable when they conflict with a task motivation which requires alertness. Berlyne interprets boredom as a state of high arousal rather than low arousal. Sensory deprivation becomes intolerable when the subject cannot sleep any more and "internal factors cause a rise in arousal and the lack of stimulation renders the cortex incapable of

keeping arousal in bounds (p 190) Berlyne makes an essential point that the optimal level of stimulation is relative to physiological sleep waking rhythms He is not too specific about the internal factors which might result in arousal in wakeful subjects except to suggest that they might be thoughts The psychoanalytic theory which will be discussed in the next section has more to say on this

Berlyne s view of boredom implies an antagonistic relationship between cognitive and somatic arousal Part of the problem with the concepts of arousal is the assumption that all systems are aroused or depressed simultaneously But as has been pointed out a person may be in a lowered state of cortical arousal but in a high state of autonomic or muscular arousal This seems to be the case in sensory deprivation where the brain waves show lowered arousal whereas the restless body movements GSR and subjective reports reflect increased affective autonomic and motoric arousal Lacey (1967) has attacked the general arousal concept and pointed out situations where activation in one system is related to deactivation in another He cites the Darrow Jost Solomon and Mergener (1942) study where blood pressure arousal was negatively related to cortical activation In another study by Darrow Pathman and Kronenberg (1946) heart rate and GSR measures of activation were negatively correlated with EEG indices In situations studied by Lacey where the organism is attending to the environment as when waiting for a signal cardiac deceleration is associated with skin conductance increase

The model of Blum Geiwitz and Stewart (1967) explicitly separates the cognitive affective and motoric networks postulating interconnected gain controls and amplifiers for each with sensory input acting specifically on each network and nonspecifically on the cognitive gain control Two feedback systems one from the effectors and one from the cognitive controlled amplifier control the sensory input and the cognitive network (see Figure 12–2) The implication of this model for sensory deprivation is that a lack of sensory input will turn down the gain control of the cognitive affective and motoric amplifiers What turns up the gain controls on the affective and motoric amplifiers? The model would seem to suggest that cognitions must be the source of such activation but shouldn t these cognitions also tune up the cognitive amplifier?

Before the popularity of the RAS the hypothalamus played a major role in physiological models for psychology Because this structure is certainly the major center for autonomic regulation and controls the endocrine gland system through its influence on the pituitary gland its importance in arousal cannot be denied Gellhorn and Loofbourrow (1963) have attempted to define the role of the hypothalamus in sensory deprivation Their assumption is that hypothalamic activity is low in sensory deprivation unless movements are permitted to activate the structure From isolation studies of animals they conclude that prolonged sensory

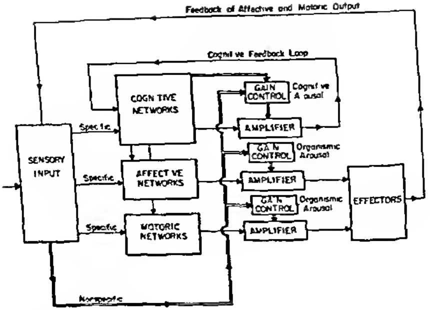

FIGURE 12–2 A model of the mind signal routes (single lines) and amplification control routes (double lines)

SOURCE Reprinted by permission from G S Blum J Geiwitz & C W Stewart J pers soc Psychol 1967, 5, 139–151

deprivation eliminates the emotional reaction to painful stimuli as well as the perception of pain itself They attribute this to the lowering of hypothalamic reactivity and its effects on perception Tactual and visual perception are also disturbed by this hyporeactivity of the hypothalamus The authors suggest that reduced sensory input should dampen the reactivity of the hypothalamus and the entire sympathetic system But such an assumption is incongruous with the lowered pain thresholds and emotional disturbances reported by human subjects in sensory deprivation The authors assume that the emotional disturbance is a result of ' incongruous sensory input and if physical discomfort could be eliminated, and the levels of stimulation could be reduced to zero a blissful, relaxed state would result In support of this notion they cite the autobiographical account of Lilly (1956) in a water submersion experiment, ignoring the fact that most subjects in subsequent experiments could not endure water tank submersion for more than 8 to 10 hours

vestigators (Gorbov, Miasnikov, & Yazdovsky, 1963, Miasnikov, 1964) have demonstrated decreased cerebral cortical activation and increased adreno-cortical activity in prolonged isolation studies reinforcing these findings by Canadian, Japanese, and American investigators The Soviet neuro physiological theory is more compatible with the physiological findings in SD, which are incompatible with general arousal theory However, some actual study of the conditioning and extinguishing of autonomic responses in various phases of SD, together with EEG study of the subjects would offer more concrete evidence in support of their theory

The McGill group (Heron 1961) has outlined a neurophysiological theory of SD Heron has divided the effects of SD into (1) nonspecific ef fects or those which affect the regulation of the electrical activity of the whole brain (2) specific effects or those limited to a single sensory mo dality, and (3) effects on the complex neural processes or what Hebb (1949) calls Phase Sequences which govern thought and action

The nonspecific effects are represented by shift toward lower frequen cies in the alpha band of the EEG after prolonged SD The ascending reticular system is thought to be affected by the reduction in variation in the sensory environment so that it can no longer maintain a normal level of activation in the cortex

The specific effects are those that are related to a specific sensory modality such as the reported visual sensations in the absence of patterned visual stimulation Doane (1955) has suggested that Cannon and Rosen blueth s (1949) law of denervation might explain these phenomena This law states that denervation results in a progressive sensitization of sites higher in the nervous system Because SD or PD result in a functional denervation they might sensitize the sensory system lowering thresholds for subsequently presented stimuli as well as resulting in the attribution of activity within these higher sites to an external stimulus affecting the unstimulated receptor The phantom limb phenomenon in amputees can also be accounted for by this theory

Hebb (1949) has stated that the neural organization which is neces-sary for thought or action is maintained by sensory flux The lack of sen sory flux because of the restriction on motor activity as well as the restriction of sensory input from the exteroceptors would be expected to disrupt thinking and the adequacy of cognitive and visual motor perfor mance

In the symposium on hallucinations (West 1962a) several authors have advanced neurophysiological theories which might explain the hal lucinations in SD or PD conditions Scheibel and Scheibel (1962) state The development of n o b (non-object bound) sensory phenomena dur ing periods of sensory deprivation may be interpreted in the light of our assumption The amount of sensory input is diminished to levels well below what is usual for an awake individual Normally periods of de

creased total output to the reticular core occur only during sleep, but in this case the individual remains normally awake. The gradual development of n o b. sensory experiences may represent simply a normal expression of the physiologic function of brain cells whose modulation by specific and nonspecific reticular input drops below a critical level, with consequent changes in cell biasing and concomitant increased sensitivity to what is usually 'background activity' in intra-cerebral loops" (pp. 29–30)

The speculations of Evarts (1962) point to the similarity between dreams and hallucinations and suggest that a common neurophysiological process may underlie both. Rather than a confused cortex misreading the locus of its own activity, Evarts proposed that the visual hallucinations may be discharges in the visual cortex caused by the release of cortical inhibition, as in sleep. Although Evarts does not deal directly with the SD or PD situations, one could deduce that some of the peculiar sensory phenomena reported might be produced by lowered arousal states. Actually, several authors (Freedman, Grunebaum, Stare, & Greenblatt, 1962; Rossi, Furhman, & Solomon, 1964; 1967; Ziskind, 1965) have suggested that the peculiar sensations, images, and "hallucinations" in SD are simply hypnogogic or dream phenomena occurring originally in states of lowered arousal.

Luby et al. (1962) interpret the effects of sensory deprivation in terms of a discrepancy between an active reception interpretation system and abnormally reduced external input. When input is reduced below the "characteristic range" with reception and interpretation systems functioning at characteristic levels, tensions accumulate which may be felt as anxiety or discomfort. Residual cues from within or outside of the subject may be "hypercathected" and result in illusions or hallucinations.

West (1962a) also advocates an arousal theory of SD hallucinations When sensory input decreases "there may be a release of previously recorded perceptions through the disinhibition of brain circuits that represent them" (p 28). If cortical arousal persists, these minor perceptions may be experienced as external. "The greater the level of arousal, the more vivid the hallucinations" (p 281).

EVIDENCE RELATING TO PHYSIOLOGICAL THEORIES

Physiological models often tend toward a homuncular type of anthropomorphism It is easy to treat the reticular formation or hypothalamus in the same way that ego or id are dealt with in psychoanalysis. However, the former two are real structures even if their functioning is only partly understood The method of implanting electrodes has added greatly to our knowledge about these structures and considerable research on infrahuman species has been done If we could plant electrodes in the reticular

and cortical structures of our human subjects and make recordings in sensory deprivation conditions, we would be on much firmer ground. As it is, human studies must rely on EEG recordings from surface electrodes and peripheral autonomic recordings or biochemical analyses to monitor changes in arousal. Although we know something of what is happening to the general rhythms of the cerebral cortex, little is known of the functioning of subcortical structures in SD.

Some questions stemming from physiological theories may be listed as follows:

1. Is the typical response to sensory deprivation one of arousal or depression, or an alternation of these states?
2. Does sensory deprivation produce hallucinatory phenomena, and if so, are these phenomena products of states of arousal or depression?
3. Are the sensory effects specific to the restricted sensory modality or are they facilitated by a general lowering of sensory input?
4. Is there evidence for a progression in the sites of sensory effects from receptors to higher centers?
5. Does sensory restriction affect cognitive activity, and is the effect inhibition or facilitation? Is the effect a motivational one or a function of changes in cortical activation? Are the effects general or related to specific types of cognitive function?
6. How general are the physiological effects, and how much are they a function of constitutional personality differences?

SD as Arousal or Depression Producing

Chapters 3 and 8 have summarized much of the evidence of physiological reactions to SD. One problem with the concept of arousal is the specificity of many of the indicators. It is possible for one physiological indicator to move in a direction of arousal while another shows depression. Lacey (1967) has shown different patterns of autonomic arousal in response to different classes of situations. Individual specificity of response has been noted in many studies. Perhaps the most relevant indicator to the theories is the EEG. Data have been presented to show that the EEG response during the first hour of isolation reflects decreasing activation.

Autonomic indicators also generally reveal an adaptation effect during the first hour or two of sensory deprivation. If allowed to, many subjects fall asleep during this period. There are some subjects who panic shortly after entering isolation, and these subjects show physiological arousal prior to quitting, but they are not typical. During the next phase, from 2 to 8 hours, physiological reactions are variable, reflecting personality or sex differences or the severity of conditions of perceptual restriction. Subjects get measurably restless but begin to settle down during the night hours. After 1 day there is typically a slowing in the EEG alpha activity with the appearance of theta and delta activity. This slowing in the waking EEG becomes more marked as isolation progresses. Large

changes are seen after 2 weeks, and the recovery time is slow, taking 10 days or more Correlated with the slowing are losses in motivation The EEG slowing is produced by movement restriction also, but it is not as marked as seen in perceptual deprivation

Although brain activity is progressively depressed during long term isolation, other indicators such as skin conductance and body movements show an increasing arousal A third of the subjects typically quit by the second day Little change is seen in adrenal medullary output except in imminent "quitters but the adrenal cortex pours out larger amounts of its hormones than are seen in normal, active days outside of confinement Most of these changes are also seen in social isolation situations and are influenced to some degree by the confinement of activity

These results are partly compatible with the theory that postulates a cerebral cortical-reticular relationship Although the action of the reticular structure in humans is unknown, we see a depression of cortical activity and an increase in autonomic and adrenocortical activity What this suggests is that when the reticular formation cannot activate the brain there is an efferent discharge which creates the neurophysiological equivalent of increased 'drive However, the theories still do not explain, from a physiological standpoint, why reduced cortical activation should result in autonomic arousal peripheral muscular activation, or negative affective response Is a need to maintain an optimal level of sensory variation a learned need or one built into the nervous system? Does the C N S adapt to lowered levels of input?

The cortical effects of deafferentation can be more readily studied in animals than in man In chapter 8 Zubek has discussed a number of such studies which show that destruction of visual auditory, or olfactory afferent systems can produce the slowing of cortical EEG rhythms which are observed in human subjects during prolonged SD A very important study by Beteleva and Novikova (1961) showed that olfactory deafferentation produced a depression of EEG rhythms and a concomitant raising of excitability of the reticular formation These changes in the reticular formation lasted 1 to 2 months after which the electrical activity returned to normal This represents the first direct evidence of the negative feedback relationship between cortex and reticular formation which has been postulated by Lindsley (1961) and others and would explain the paradox of lowered cortical activation and increased autonomic and efferent activity seen in SD

Arousal and Hallucinations (RVSs)

There are several lines of evidence that suggest that the sensations reported in the absence of stimulation occur in moderately aroused states rather than in sleep or borderline sleep states Firstly there are the high negative correlations between sleep ratings and complexity of images or

RVSs found in the Holt and Goldberger (1961) and Zuckerman Albright Marks and Miller (1962) studies Secondly there is the Murphy Myers and Smith (1963) finding that subjects who are kept alert and wakeful prior to reporting RVSs report more complex RVSs than those who are allowed to become drowsy or sleepy Thirdly encouraging spontaneous reporting increases the number of subjects giving RVSs Although this could be a self suggestion effect it is equally plausible that spontaneous reporting keeps subjects in an alerted aroused state Fourthly and most importantly the EEG patterns prior to reported sensations generally indicate wakefulness (Zuckerman & Hopkins 1966) Although Rossi Furhman and Solomon (1964 1967) have offered data which they claim indicates that reports of imagery originate in sleep states their method was more likely to elicit dream reports rather than imagery reports Clearly subjects do sleep and dream during SD and dreams may sometimes be reported as perceptions but the RVS phenomena can be distinguished from dreams (Leiderman 1962) and they can occur in a wakeful but functionally deafferentated subject Rossi Furhman and Solomon (1967) have also presented evidence that fantasy and thought disorganization are more likely to occur in states of lowered cortical activation whereas reality-oriented thoughts and daydreams are more likely to occur when the subject is awake in sensory deprivation

Are the Sensory Effects Specific and/or General?

Doane s (1955) application of Cannon and Rosenblueth s (1949) law of denervation which states that denervation results in a progressive sensitization of sites higher in the nervous system suggests that the functional denervation of SD should lower thresholds for the specifically affected systems The theories of Scheibel and Scheibel (1962) and Luby et al (1962) seem to use a similar cortical sensory sensitization hypothesis to explain the hallucinatory type phenomena of SD The sensoristasis theory of Schultz (1965) and the homeostat theory of Lindsley (1961) postulate a more generalized central mechanism mediated by the reticular formation These theories might predict cross modality effects i e functional denervation of any primary sensory system such as vision or audition should increase sensitivity of other modalities Zuckerman Albright Marks and Miller (1962) suggested that much of the somatic discomfort in SD may be a function of increased sensitization to interoceptive and somesthetic sensations because of the absence of competing stimulation from the exteroceptors Normally exteroceptive stimulation tends to dominate the perceptual field and reduces sensitivity to interoceptive and somesthetic sensations

In chapter 7 Zubek has summarized some of the relevant evidence on single modality restriction It would appear that prolonged periods of visual deprivation alone can produce significant increases in cutaneous

auditory, gustatory, and olfactory sensitivity, effects which, with one exception (olfactory sensitivity) have also been demonstrated after prolonged sensory and perceptual deprivation (p. 252). Zubek interprets this evidence as supporting the Schultz and Lindsley sensory homeostatic theories.

Central sensitization produced in the specifically isolated modalities is also apparent. Areas of the skin which are occluded, as well as their homologous areas on the contralateral limb, which are not occluded, show increased tactual sensitivity after periods of occlusion. Constant pressure stimulation resulted in a decrease in tactual acuity. The occurrence of the effects in homologous nonoccluded areas suggests a central effect in the somesthetic area of the brain rather than a local effect in the isolated area of skin. This evidence constitutes some of the best proof available for the application of the Law of Denervation.

In chapter 4, data were presented extending these hypotheses to the hallucinatory phenomena. A number of studies have demonstrated that the reported visual sensations show a progression toward increasingly more complex and meaningful ones. The subjects first report diffuse blobs, then geometrical forms, then patterns, then objects, and, finally, integrated, animated scenes. This progression suggests a shift from idioretinal phenomena to more meaningful images with their sites higher in the nervous system. The intermodality effects of single sensory restriction were also reported. Visual restriction produces more reports of visual images than nonrestriction, but the addition of auditory restriction does not facilitate these phenomena. Similarly, auditory deprivation produced auditory "hallucinations", but visual deprivation did not add to this effect. But visual *and* auditory deprivation combined produced significantly more somesthetic illusions and hallucinations than either one alone. This result is interesting in light of the inconsistent results on the lowering of auditory and visual thresholds in SD compared to the more consistent findings of lowered pain and tactual thresholds. The results support the theory that SD increases sensitivity to somesthetic stimuli because of a lack of competition from exteroceptive stimuli. It is also consistent with the known analgesic qualities of noise. The reduction of exteroceptive stimulation provides somesthetic stimuli with a clear track to the brain, whereas in the presence of exteroceptive stimuli these afferent impulses may often be shunted off to the sidetracks of the reticular formation. Jacobson (1966) has used the theory of Zuckerman, Albright, Marks and Miller (1962) to predict that, because of increased body sensitization, subjects in SD should improve their performance on the Rod and Frame test. This test measures the extent to which one can use one's body cues rather than conflicting visual cues to estimate the vertical or upright. Jacobson's data supported the hypothesis. In the laboratory at Albert Einstein Medical Center, Philadelphia, this hypothesis is being checked in an experiment of 8 hours with additional movement restriction.

The perceptual facilitative effects of SD noted in these experiments are particularly interesting in view of the fact that many kinds of more complex perceptual performances show a decrement after SD (Zubek chapter 7) SD may in some cases sensitize the brain to stimulation but the disorganization of brain functioning may interfere with the integration of impulses

The specific sensory effects of SD suggest the involvement of the primary sensory systems the cross modality effects suggest the involvement of the nonspecific activating systems All of the data suggest the fruitfulness of a sensory homeostatic or optimal level of stimulation model for SD phenomena The striving of organisms to increase exteroceptive stimulation in its absence (i e see Jones chapter 6) also suggests such a model

Cognitive Effects

The cognitive effects of sensory deprivation may be predicted from a motivational or a purely cognitive viewpoint The motivational viewpoint would relate the effects of SD to the level of arousal produced by SD If arousal is equated with the modified drive concept then the prediction of an inverted U shaped relationship between efficiency and drive for complex or cognitive tasks would yield the prediction that if SD produces moderate arousal it will facilitate cognition but if it produces very low or very high arousal it will interfere with cognitive activity At the physiological level Hebb (1958) has pointed out that the nonspecific projection system and arousal provide a diffuse bombardment of widespread cortical regions increasing the likelihood of summation at synapses and thus making cortical transmission more feasible Moderate arousal may increase the likelihood of a particular phase sequence (set of cell assemblies or neurons in closed pathways) firing but high arousal may activate many phase sequences which have no relevance to preceding phase sequences The predictions from this line of reasoning are the same as those which would follow from drive theory However Hebb s theory ties the concept of arousal more closely to cortical activation whereas drive theories may be applied to autonomic concepts as well The definition of the arousal effects of SD depends on whether one looks at cortical or autonomic and effector effects Another problem in making predictions from arousal theory is that the actual testing of cognitive performance changes the level of arousal Suedfeld (chapter 5) has hypothesized that tasks at the end of a battery of tests administered after SD may be less likely to show SD effects than tasks given immediately after SD

Apart from these motivational effects of SD the absence of external stimulation may have purely cognitive effects If we accept an interference theory of forgetting then the absence of interfering stimuli during SD should facilitate memory relative to normal stimulation conditions Simi

larly the absence of distracting stimuli may facilitate performance on tasks requiring attention e g digit span and vigilance

The evidence on cognitive effects has been summarized by Suedfeld in chapter 5 Facilitative effects of SD are almost entirely confined to memory vigilance and simple learning tasks but the results are not entirely consistent for these tasks with the modal number of studies showing no effects of SD Most studies of tasks involving what Suedfeld calls moderate complexity also show neither improvement nor impairment as a result of SD It should be noted that some of these such as reasoning tasks would be called high complexity tasks by others The greatest impairment is found in what Suedfeld calls complex tasks These tasks include verbal fluency visual and oral TATs and Rorschachs Word Association Uses and Free Association Almost all of these methods could be classified as projective or free response and all call for an ambiguously defined (no right or wrong answers or definite solutions) and self sustained verbal response Most often the SD condition produces a simple decrement of response (fewer words spoken) rather than changes in the content or type of response (e g less common associates or specific themes) A major question which is as yet unanswered is whether the decrement of verbal response is due to interference with associative processes loss of motivation or inhibition of verbal response Subjects frequently report all three types of difficulty in their subjective reports

This specific type of deficit is difficult to explain from the viewpoint of physiological theories The results are also difficult to interpret because the free association tasks have been most often given at the outset of a battery of tests Perhaps the most parsimonious explanation is that the SD subjects were in either a state of lowered cortical activation and thus disinclined to talk (just as it is difficult to speak for a while after awakening from sleep or in a drowsy state) or were so aroused that they were paralyzed by response competition The former theory seems more applicable for most subjects Unless there is some equation of arousal for SD and non SD subjects the cognitive effects of SD cannot be properly appraised and in the absence of such comparisons differences in arousal or motivation may account for the effects found

PERSONALITY THEORIES

Physiological

Almost all persons investigating physiological responses have commented on the range of individual differences Zuckerman et al (1966) have noted many consistencies of relative individual response going from a SD to a Social Isolation situation Some investigators have attempted to define these individual differences in terms of physiological or perceptual physiological type theories

Petrie, Collins, and Solomon (1958, 1960) offered an ingenious hypothesis which postulated that individual differences in tolerance for SD could be explained on the basis of a physiological trait, 'satiability' Satiability may be defined as the speed with which a stimulus trace fades Kohler and Wallach (1944) defined satiation as the apparent diminution of perceptual intensity after prolonged stimulation with a stronger stimulus Petrie, Collins and Solomon (1958) have related satiation, defined by tactual stimulations, directly to pain tolerance and inversely to SD tolerance The latter finding was interpreted in the following manner 'the tendency to reduce (i e , become satiated) should be a handicap in a situation where the environment starves the individual of sensory experience instead of bombarding him with it, as is the case for pain' (p 84) In other words, the person with a nervous system which doesn't retain sensory traces of stimulation should be even more sensorily deprived than a person who can utilize residual sources of somesthetic or other stimulation Besides assuming the generality of the satiation phenomenon across sensory modalities the theory makes the assumption that those who can retain stimulation have the greatest tolerance for SD Zuckerman Albright, Marks, and Miller (1962) found that subjects who were most attentive to residual auditory stimulation in an SD situation with imperfect soundproofing reported the most stress in SD More direct evidence against the hypothesis is offered by Peters Benjamin, Helvey, and Albright (1963) and Zubek (1963b) who found no significant relation between pain endurance and SD tolerance and a trend toward a direct, rather than an indirect, relationship between the two types of tolerance

Subjects with high satiation tendency, called 'reducers by Petrie, are considered by Eysenck (1957) to be persons with an inhibitory type of nervous system These persons are thought to be extraverts at the behavioral level and to exhibit slow conditioning and low tolerance for routine or repeated behavior If we extrapolate from Petrie s theory to Eysenck s we might predict that extraverts would adapt more poorly than introverts to SD The positive findings that are available (Rossi & Solomon, 1965, Tranel, 1962 Zuckerman et al 1966) indicate the contrary, that extraverts adapt better to SD than introverts Negative findings (Rossi & Solomon 1966) indicate no relationship between introversion extraversion and SD tolerance Thus, there is little support of deductions from Petrie s theory in the SD findings Rather, the findings point to a generalized stress tolerance rather than a specific type of SD tolerance

Perceptual

A similar approach to individual differences is the theory relating field dependency to SD maladaptive response (Cohen Silverman & Shmavonian, 1962a) The concept of field dependence independence, developed by Witkin et al (1962) relates field independence to the concept

of differentiation The field independent is sensitive to his body sensations and therefore is more able to orient himself in space or judge the upright in the face of conflicting visual (field) cues The field-dependent subject is more dependent on visual cues for orientation and is more likely to be influenced by them He has a less differentiated body image and is less able to extract a simple figure from a complex field

Cohen (1967) has attempted to relate the body field concept to other similar constructs The field dependent is said to be outer directed, extraverted nonreducer, repressor, high in hypochondriasis and low in ego strength conforming possess diffuse body boundaries and is said to resemble brain damaged and aged subjects in tactile discrimination, conditional reflexes, and neurologic tests From this indictment of the field dependent, the prediction that he would not adapt well to SD follows as night does day Cohen, Silverman & Shmavonian (1962a) have offered evidence to support this hypothesis In a 2 hour SD experiment field-oriented (or field dependent) subjects gave more verbal report, body movement, and skin resistance indications of arousal than body-oriented (or field independent) subjects The experiment was repeated giving both types of subjects a placebo, sedative, and stimulant Given a placebo the body-oriented group showed a decrease in arousal in SD whereas the field-oriented group showed an increase Given a sedative, both groups showed a decrease in arousal in SD Given a stimulant the body-oriented group showed a marked increase in arousal in SD whereas the field-oriented group showed a decrease in arousal! Cohen (1967) has interpreted these results as indicating that the field-oriented (dependent) subject is stressed by SD because of the absence of familiar visual cues for self-orientation and the lack of compensating proprioceptive awareness The stimulant drug is said to make the field-oriented subject more conscious of his proprioceptive sensations by increasing sympathetic tone With the increased clarity of internal sensations, there must be an increase in orienting information within the CNS and a secondary adjustment with relaxation to his environment (p 94) This explanation seems rather inconsistent If the field-oriented showed decreased arousal after being given the stimulant in SD how can it be said that they had increased sympathetic tone? Why did the placebo increase arousal in the field-oriented group? A clue comes from another experiment by Culver, Cohen, Silverman and Shmavonian (1964) In this experiment, half of the subjects in each perceptual mode group were prepared for the experiment by preinforming them of the conditions whereas the other half of the subjects were uninformed 'The psychological data suggested that uninformed field dependent groups were more aroused and uncomfortable than uninformed field independent subjects or than field dependent subjects who had received information about the experiment (p 94) No overall difference in GSRs between field independent and dependent groups was found These data suggest that

the affective arousal of field dependents to a short 2 hour SD experience is a response to uncertainty rather than a loss of orientation cues In the first 2 hours of SD the subject may either be waiting for something to happen or he may fall asleep Because the field dependent person is supposed to be more suggestible he may be more expectant in an unstructured situation The sedative or stimulant drug effects may be reassuring to the field dependent subject because they provide a rationale for the experiment and reassure him that the experimenter has no other surprises for him What we are suggesting is that the field independent dependent personality dimension is more related to the reaction to the psychological ambiguity of the SD situation than to its perceptual deprivation characteristics The results from a recent experiment by Zuckerman Persky Link and Basu (1968b) support this hypothesis The Embedded Figures Test (EFT) correlated significantly with a number of stress measures in a sensory deprivation plus movement restriction situation however the correlations were only found in a group who were put in sensory deprivation on their first occasion in the laboratory The EFT was not predictive of the responses of another group who received sensory deprivation after having spent a previous day in the laboratory in control conditions and took an isolation questionnaire which informed them beforehand of possible reactions to isolation

Psychoanalytic

Probably the earliest psychoanalytic paper with relevance to SD is Fenichel s (1934) paper on boredom He defined boredom as a state of instinctual tension in which the instinctual aims are repressed but in which the tension as such is felt The instinctual aims are of course libidinal It is interesting that Berlyne (1960) also suggests that boredom is a state of high arousal and not a state of low arousal

Psychoanalytic personality theory has been applied to SD phenomenon by Azima and Cramer Azima (1956) Azima Lemieux and Cramer Azima (1962) Goldberger and Holt (1958) Goldfried (1960) Kubie (1961) and Miller (1962) The relative emphases of these theories vary but the essence is similar Sensory deprivation cuts the ego off from reality resulting in an increase in primary process thinking (alogical hallucinatory) a decrease in the efficiency of secondary process thinking (problem solving logical processes and goal direction) an upsurge of influence from the id (aggressive and sexual impulses) and regression in prolonged SD

Azima and his co-workers have stressed the disorganization of the body image and the regressive nature of life in the dark room with its demand feeding and demand-evacuation They felt that there was an inverse relationship between the expression of aggression and changes in the body schema When aggressive feelings are repressed or turned

against the self, difficulties referable to absence of the body schema occur The repression of aggression is also related to depersonalization tendencies The hypotheses of these authors were based upon the reactions of 15 psychiatric cases perceptually isolated for 2 to 6 days Two obsessional neurotics manifested acute psychotic episodes requiring electric shock therapy a dramatic illustration of the regression theory

Goldberger and Holt (1958) based their interpretation of SD effect on Rapaport s (1958) and Gill and Rapaport's (1959) theory of ego autonomy According to Rapaport, a person who is tolerant of his id drives, has a strong ego structure and is capable of engaging in primary process thinking without losing control or feeling threatened, can tolerate the temporary loss of reality supports The concept is related to Kris s (1952) conception of regression in the service of the ego, a mechanism by which artists or other persons can allow themselves regressive fantasies in order to use such material constructively The therapeutic use of LSD is an example of this idea Goldberger and Holt have suggested that ego strength, flexibility and the ability to tolerate primary process thinking are what determine tolerance of the SD experience They have offered support for this theory in terms of correlations between preisolation measures of ego strength (MMPI) and a Rorschach measure of adequacy of primary process handling, and various verbal content measures of adaptive and maladaptive reactions during isolation Wright and Abbey (1965) have provided further evidence of postdiction of isolation endurance using a control of primary process score on ink blot responses Zuckerman et al (1966) and Zuckerman, Persky, Link, and Basu (1968a) have shown that primary process types of scores in the Myers questionnaire (dreams, reported visual sensations and loss of touch with reality) are the scales which distinguish SD effects from those of social isolation or simple confinement Myers (see chapter 9) has identified an Unreality Stress factor in his questionnaire as well as a Positive Contemplation factor and the Zuckerman group at Albert Einstein have generally confirmed these factors in their analyses of scale relationships These data also support the Goldberger and Holt hypothesis because they suggest that there are indeed two modes of reaction to SD, apart from the General Tedium Stress One is a negative, anxious reaction because of the threatening nature of the loss of touch with reality' , the other is an enjoyment of self appraisal, memories and other contemplative responses Zuckerman, Persky, Link, and Basu (1968a) found that anxiety increase in SD on an independent checklist measure, was highly correlated with questionnaire scales ' inefficiency in thinking and loss of touch with reality However the part of the psychoanalytic theory which suggests that aggressive and sexual drives are intensified by SD and constitute the stress of SD is not supported by the data The Myers questionnaire contains scales measuring sexual and hostile thinking These scales were not affected any more by SD than by

social isolation or simple confinement. They did not load on the "unreality stress" factor and were not correlated with anxiety increases on the checklist anxiety measure. It is possible that the primary process stress is really due to the inability to cope cognitively with the impoverished SD environment. Some habitually active, goal oriented persons are threatened by a situation where they cannot control their thoughts. One does not need to postulate the emergence of repressed libidinal drives to predict that such persons might be stressed by SD.

Kubie (1961) has suggested that the differentiation between the "I" and "non I" world depends on the balance between interoceptive, proprioceptive, and exteroceptive input. Because the interoceptive input is unimpaired by SD, as in sleep, these stimuli may be the basis for waking illusions and hallucinations in SD.

The psychoanalytic theory of SD seems to point at some of the unique sources of stress in SD. However, one does not have to bring in the triumvirate of ego, id and superego or classify thinking into primary and secondary process to handle these data. Any personality theory which includes cognitive styles can deal with the phenomenon of why some people can think without the support of concrete stimulation and others can not. Suedfeld will present one such theory in the following chapter.

Other psychoanalytic theories have been neglected by SD interpreters. Karen Horney (1945) for instance, has defined primary anxiety as isolation and helplessness in a potentially hostile environment. This definition could be used as a guide to predict who will become anxious in SD and why. One reason why more persons do not become anxious in SD is that they know, or feel sure that they are being monitored and are not really isolated or helpless. One wonders what the reactions would be if subjects were put into locked and unmonitored SD chambers for indefinite time periods. Most subjects also have a basic trust in the experimenters and do not conceive of their environment as potentially hostile. In a few cases subjects without this trust have developed delusions of threat (e.g., poisoned or drugged food, gas in room, turning up temperature, electric shocks, etc.). Thus Horney's theory of primary anxiety points to the interaction between the experimental set and the subject's personality as a determinant of SD affective responses. Orne and Scheibe (1964) have demonstrated how a particularly threatening type of experimental atmosphere can produce affective reactions to an innocuous isolation situation. Conversely Persky, Zuckerman, Basu and Thornton (1966), Zuckerman et al. (1966) and Zuckerman, Persky, Link and Basu (1968b) have found that an initial confinement exposure or even a day spent in another room of the laboratory prior to the confinement day reduces much of the subjective (questionnaire) stress on the subsequent experimental day. The perceived relationship between the experimenter monitor and the subject is an unexplored aspect of SD work.

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pect of SD work

sponding to almost any stimulus if it is presented repeatedly and close in time. The concept of habituation can be applied to more complex stimuli to account for boredom with familiar faces and surroundings and the need for novelty in all sensory modalities. But to account for these phenomena we must assume that for many or most persons very low levels of stimulation and arousal are not optimal.

II. *The arousal potential of stimulation is inversely related to the immediate level of arousal at the time of stimulation.* This is similar to Wilder's (1957) Law of Initial Limits except that the latter is applied to specific arousal channels whereas this theory pertains to the totality of stimulation at a particular time and the general level of arousal just prior to that time. A person in a generally high state of arousal will not respond markedly to situations which are arousing to others (e.g., Glickstein et al., 1957).

III. *Every individual has characteristic optimal levels of stimulation (OLS) and arousal (OLA) for cognitive activity, motoric activity, and positive affective tone.* The idea of individual differences in OLS and OLA have been suggested by many in relation to sensation seeking (Zuckerman, Kolin, Price, & Zoob, 1964), arousal seeking (Schubert, 1964), and sensoristasis (Schultz, 1965). The obvious evidence of these differences are all around us. Contrast the individual who needs absolute quiet for cognitive activity and the person who can work only with the din of music and voices around him. Consider persons who manage their lives so that every event is repeated, regular, and predictable, and those whose lives are in a continual uproar because of their need to vary their stimulation and maintain a high level of excitement. These types of persons can seldom understand one another. If they are psychologists, they are likely to sum up their opposite as "psychopath" (high sensation seeker) or "obsessive-compulsive" (sensation reducer) without really inquiring into the needs underlying his behavior. Those who see "anxiety" behind all such behavioral expressions are often mistaking cause and effect. Equating anxiety with arousal, it is probable many persons behave as they do not because they are driven to reduce "anxiety" but because they are driven to increase "anxiety."

The concept of Sensation Seeking is related to, but not identical with, Eysenck's "extraversion" (Farley & Farley, 1967).

Optimal levels of stimulation will vary with the following factors:

A. *A constitutional factor*: possibly reactivity and "satiability" of the central and autonomic nervous systems to specific classes of stimulation or the "strength" of excitatory and inhibitory centers in the central nervous system.

B. *Age.* OLS is lower in children, reaches a peak in adolescence, and declines thereafter. Young children are more prone to be frightened by unfamiliar or intense stimulation and seem to enjoy repetition of the familiar more than older children or adults. Brownfield's (1966) study has shown a decline in scores on the Sensation Seeking Scale (Zuckerman, Kolin, Price, & Zoob, 1964) from ages 15 to 65.

C. *Learning Experiences.* Presumably, individuals can eventually adapt to successively higher levels of stimulation if these are increased in a gradual fashion or, conversely, can adapt to successively lower levels of arousal. Adaptation consists of a raising or lowering of cortical activation with the increase or decrease of stimulation and a lowering of autonomic arousal. The OLS may be shifted by varying periods of severe understimulation or overstimulation. The duration of the shift in OLS is about proportional to the duration of the prior period of isolation.

D. *Recent Levels of Stimulation.* Individuals who have been overstimulated for a limited period of time (relative to their own OLS) prior to the current period will seek lower levels of stimulation; conversely, individuals who have been understimulated for a limited period of time prior to the current period will seek higher levels of stimulation. This will not be true if adaptation has taken place and the OLS has shifted.

E. *Task Demands.* OLS's will vary with the type of task demand. A task demand requiring attention, self-sustained cognitive effort, or fine perceptual discrimination will generally require moderate levels of arousal. Simpler tasks requiring little cognition or involving few competing responses demand higher levels of arousal.

dividual to cope with the phenomena described in the following postulates

V Positive affective tone is usually associated with moderate levels of stimulation and arousal which do not deviate too far from the OLS Negative affective tone is associated with very low or very high levels of stimulation and arousal relative to OLS

VI A Generally moderate levels of cortical activation are necessary for sustained self directed cognitive activity The type of activity most affected will be the type where the task is unstructured and a chain of associations must be verbalized

B Sensory stimulation is necessary to maintain cortical arousal and sustained self directed cognitive activity, but too much sensory stimulation arriving simultaneously at the cortex results in very high cortical arousal and disrupts cognitive sequences

VII In the absence of directed cognitive activity, but with diffuse stimulation from the ARAS, excitation spreads along diverse pathways in associative areas of the cortex leading to an increase in 'primary process thinking The lack of control over cognition is threatening to some persons and may result in anxiety

VIII The disorganization of the cortex by very low or high cortical activation, relative to OLS releases inhibitory influences over cognition and control of emotional reactions, which may lead to heightened suggestibility or exaggerated emotional reactions to minor worries or annoyances

IX The disorganization of the cortex by low or high cortical arousal, relative to OLS may cause confusion of orientation in the absence of external cues (SD) Misreading kinesthetic and somesthetic sensations (body illusions) or the locus of visual or auditory imagery (hallucinations) may be the result

X A When a sensory modality is isolated from stimulation sensitization or excitability is increased in areas in the central nervous system which mediate that modality Sensitization also occurs in other nonisolated modalities

B There is an inverse relationship between the exteroceptive and somesthetic or interoceptive sensory systems A decrease in exteroceptive stimulation results in increased sensitization to somesthetic stimulation An increase in exteroceptive stimulation tends to block somesthetic afferent stimulation probably at the reticular formation

CONCLUSIONS

The ultimate value of sensory deprivation research will be found in its contribution to behavioral theories The motivational theories of the

1930s placed a relatively great importance on specific physiological drives such as hunger, thirst, sex, and pain avoidance Stimuli were considered in a motivational role insofar as they activated such drives through conditioned or unconditioned associations In the last two decades, the nonspecific role of sensory stimulation in maintaining arousal and tonus has been recognized Research indicating the importance of early stimulation for later learning perception, and motivation led to studies of the effects of sensory restriction in adult humans From these studies has come the recognition that sensory stimulation is not just secondary reinforcement or discriminative cues Sensory variety is not just the spice of life, it is the bread of life However, it is a large step from the recognition of this need of higher organisms to the incorporation of the data into behavioral theories Many theorists are like the blind men feeling different parts of the elephant The physiological theorist and the personality theorist do not even appear to be feeling the same elephant But despite our disagreements we all agree that something is there and most of us agree that it is rather large A single variable approach to the study of the phenomena is not likely to yield much understanding of the beast Similarly a single level of theorizing whether cognitive, personality, or physiological, is not likely to be adequate The insular purity of the empty box theorist and the sweet innocence of the physiological reductionist will be increasingly hard to maintain as more sophisticated data from psychophysiology demand the attention of theory Theories which purport to explain the phenomena of sensory deprivation must be capable of explaining all of the data including social influences individual differences and slowed brain waves Theories such as Field Orientation and Optimal Level of Stimulation seem to be most suited for the purpose because they employ models which translate readily into physiological *and* behavioral terms and adapt well to the study of individual differences

13

Theoretical Formulations: II

Peter Suedfeld

The theoretical formulations discussed in this chapter are those whose central concern is a cognitive one. Although they are not equally explicit on the matter, expectation hypotheses and information-processing hypotheses both emphasize that man needs structure to function optimally. When that structure is taken away, as it is in SD—when one does not know *the "right thing to do,"* cannot evaluate the consequences of one's acts, or is deprived of informational feedback and stimulation—the individual will seek out and attach himself to whatever cognitive anchors, external or internal, are available.

THE EXPECTATION HYPOTHESIS

Anticipation, instructional set, and role playing by experimenter and by subject—the "social psychology of the psychological experiment" (Orne, 1962)—have recently become matters of concern in many lines of research. Matters of concern, that is, to the few who are busily documenting the phenomenon; but matters frequently shrugged off by many other workers. Nevertheless, the evidence that these factors can significantly affect experimental results is plentiful and persuasive. Several recent reviews demonstrate the quantity of relevant data (Masling, 1960; 1966; Rosenthal, 1964; 1966), and the number of different experimental settings and techniques in which the effects have been found establishes the weight of the argument. In this section the term "expectation" is used to include the effects of tacit and overt suggestion, of prior knowledge or experience, and of role playing.

Among SD researchers, the staunchest advocate of the expectation hypothesis has been C. W. Jackson, Jr. He and his co-workers have argued cogently that "The subject's prior knowledge of the expected or anticipated effects, his motivation to experience and report, or not to experience and not to report . . . are variables that are generally underemphasized

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but are clearly of great importance (Jackson & Pollard 1962) In fact the abstract of the article from which this statement is quoted begins with the famous dialogue between Hamlet and Polonius in which the former suggests—and the latter accepts—various interpretations of a presumably inkblot shaped cloud (Hamlet, Act III Scene 2)

Several sources of expectations can be identified in the SD situation The subject may have experienced SD previously or may have some knowledge of previous SD results from earlier subjects from popular media or from the scientific literature The experimenter playing the role of Hamlet, may explicitly suggest to the subject what he should expect (Let me know every time you see an hallucination) or may communicate such suggestions implicitly in his instructions (This is the panic button just in case) Of course this may result either in compliance or in what Masling (1966) has called the Screw You effect the determination not to give the experimenter what the subject thinks he wants Last the expectations of the experimenter may affect the way he himself treats the subject the way he administers his tests or the way he scores the data Let us take up these sources of bias in order

The effects of repeated SD sessions are discussed in chapters 3 5 and 9 Generally an adaptation phenomenon is found in that subjects report and show fewer SD symptoms the second time Why don t subjects experience these presumably anticipated symptoms? For one thing, adaptation to SD itself may cancel them for another reduced uncertainty and stress—the fact that the subject knows from actual experience what to expect—may eliminate those SD phenomena which arise from the lack of such knowledge prior to the first session This uncertainty reduction explanation (to which we shall return later) is bolstered by the findings of many investigators that the attrition rate as well as the occurrence of negative reactions goes down when their procedure involves such steps as familiarizing the subject with the chamber the instruments the duration of the session etc. before confinement (see chapter 9)

Incidentally one frequently reads that SD is a laboratory analogue of such situations as space flight Arctic weather observation or radar operation to test the consequences of real life previous experience we should have experiments drawing subjects from experienced radar operators nuclear submariners spelunkers and the like It would be interesting to see how the personality and experiential parameters involved would manifest themselves in the laboratory

Previous knowledge from second or third hand sources raises problems of accuracy With the popular news media novels and movies all having contributed to the linking of SD with such phenomena as insanity and brainwashing the direction of suggestion is obvious Subjects who derive their expectations about SD from these sources will probably be more anxious and more certain that they will experience bizarre events

Jackson and Pollard (1966) reported that 36 of 48 college student subjects knew one or more items of information about SD conditions and outcomes were able to associate SD with other research areas etc Their information tended to be on the dramatic side effects such as hallucinations and neurotic behavior and the relation of SD to space travel concentration camps ESP and so on were prominent responses It is clear that SD subjects who tend to be drawn from college populations arrive at the laboratory with a fairly extensive although biased set of expectations

Although Reed (1962) reported that expectation of effects was positively related to their occurrence the evidence on this point is inconclusive Zuckerman and Cohen (1964b) found no correlation between previous knowledge and hallucinations although only 40 percent of subjects who claimed to have no expectations about SD reported hallucinations contrasted to 61 percent of those who did have expectations this trend was not statistically significant In view of the fact that the simplest type of visual sensation was in general found to be influenced by experimental suggestion it is regrettable that there was no specific report of the correlation between such sensations and expectation

The communications of previous subjects may be biased such subjects may emphasize the dramatic aspects of their confinement or in talking about the tasks involved may predispose their listeners to certain kinds of responses When subjects are asked—or made to swear dire oaths—not to discuss the session a self selection procedure probably determines their cooperation This factor an important one in many kinds of research has only recently begun to undergo empirical investigation (Wuebben 1967)

Suggestions from the experimenter whether explicit or not have been demonstrated to be a significant variable in psychological research (see Masling 1966 Rosenthal 1966) Orne and Scheibe (1964) showed that an experimental situation made somewhat threatening by the use of medical props and described and labeled as SD resulted in more SD effects than an identical situation presented as a control treatment and without the stage setting One wonders whether some degree of suggestion was operating in *both* directions rather than as the authors assume the demand characteristics of the experimental treatment being solely responsible for differential performance

Orne and Scheibe s data may also be interpreted as the result of a perfectly legitimate experimental technique the induction of psychological stress some of whose consequences are similar to those of SD In the same way hunger and thirst have some similar consequences (increased activity the strengthening of dominant responses, and so on) although no one would argue that one is a contaminant of the other The common consequence may be arousal and one should not be surprised that the threatened subjects of Orne and Scheibe in fact show arousal effects just as

nonthreatened SD subjects have done (Suedfeld Glucksberg & Vernon 1967)

As has already been mentioned the presence of a panic button and related features of the orientation procedure may tacitly indicate what the experimenter expects to happen Other sources of implicit suggestion are present in many pre SD procedures Some experimenters conduct a question period concerning physical and mental health some programs require a brief psychiatric interview and in some cases subjects must sign release forms relieving the institution and the experimenter of liability in case something happens Zuckerman (personal communication) has pointed out that an austere and forbidding laboratory atmosphere and the thick walled, thick-doored tomb-like SD chamber have their own suggestive characteristics So do attached wires and electrodes in studies using physiological measures As in the Orne and Scheibe experiment anxiety may be aroused with the resultant data being at the very least contaminated by this factor

One might also consider the affective concomitants of the water immersion procedure with the mask the air hose and the strangeness of the element Even disregarding its stimulus-reducing properties this technique would surely result in more dramatic effects than room confinement!

It is in the area of explicit experimenter suggestion that the greatest amount of empirical work has been conducted On the positive side we have the reports of Kandel Myers and Murphy (1958) Jackson and Kelly (1962) Pollard Uhr and Jackson (1962) Schaefer and Bernick (1962) Ziskind (1964b) and Murphy (1966) All of these experimenters varied the extent to which subjects were led to expect certain kinds of phenomena (most frequently hallucinations) and/or the degree to which these expectations were structured by the experimental instructions and all of them found that these instructional variables were positively associated with the phenomenon involved On the negative side there are the papers of Rossi Sturrock and Solomon (1963) and of Short and Oskamp (1965) both of which report a lack of suggestion effects on the occurrence of visual sensations Zuckerman and Cohen (1964b) found that vague changes in perceived illumination were reported more frequently by a suggestion than by a control group although complex visual sensations were not amenable to suggestion

Jackson and Pollard (1966) point out that in the studies which purport to demonstrate a lack of suggestion effects the control or no-suggestion group may in fact have expectations derived from other sources The result of this would be that both groups would in fact enter SD with very similar attitudes and the lack of behavioral differences would prove nothing This argument has merit For one thing the negative results merely succeed in proving the null hypothesis for another Zuckerman

and Cohen point out that "It is the high percentages [of reported visual sensations] in our control and mild suggestion groups which account for the lack of significant differences" (1964b, p. 659). In other words, all of their subjects in an experiment run approximately 2 years after that of Jackson and Pollard (1962) behaved like the latter's suggestion group. If we consider the spread of knowledge about SD phenomena which may have occurred during the time lag, Jackson and Pollard's (1966) hypothesis seems quite reasonable. Could it be that the ineffectiveness of direct suggestion is related to the growing sophistication of subjects, which makes such suggestion redundant? And if so, what other areas of psychological research are being affected by the same process?

The problem of unwitting suggestion or differential handling is a thorny one and threatening for all investigators. The honesty of the researcher is not in question, and we therefore have to assume that he is unaware of his own confounding of the data. No work has been done to evaluate the importance of such variables in SD experiments, but there is persuasive evidence concerning their role in a variety of other areas (Rosenthal, 1966). The maximal automation of testing and scoring procedures, the use of blind and double blind scoring and analysis, and perhaps the employment of research assistants who are ignorant of the variables and hypotheses involved should reduce the hazard.

(Schroder, Driver, & Streufert, 1967), field-dependent individuals (Witkin et al 1954), or people who score high on tests of suggestibility, regardless of underlying personality variables (Cambareri 1959)—may give us data in which suggestion effects play a disproportionate role *vis-a vis* SD effects

For example, the expectation hypothesis has been used to explain a personality difference relevant to SD Dohrenwend and Dohrenwed (1966), using anxiety arousing instructions found that first born subjects reported more symptoms of psychological distress occurring in an 8 hour PD session than did later borns Furthermore, only 7 of 16 volunteers for the experiment were first borns (Dohrenwend, Feldstein Plosky, & Schneider, 1967), in contrast to almost 80 percent of the volunteers for an SD study with a reassuring recruiting text (Suedfeld, 1964c) A more recent study indicated that while minimal recruiting information resulted in equal degrees of anticipated SD stress among first and later borns a reassuring approach led to significantly reduced anticipated stress for first borns only (Suedfeld, in press) Apparently, first borns are more susceptible to instructional set, a conclusion which is compatible with other ordinal position data (Sampson, 1965) The extent to which this difference leads to performance differences while in SD remains to be investigated

Cambareri (1958) in what is undoubtedly the area's most frequently cited unpublished dissertation demonstrated that suggestible subjects tolerated water immersion SD longer than less suggestible people, generated more hallucinations and fantasies, and were less threatened by various unusual experiences These differences were associated with an expectation difference suggestible subjects (like first borns) perceived the experiment the way it was explained to them as an SD study, nonsuggestibles saw it as a stress study

To sum up, there is no real evidence that expectation is either sufficient or necessary for the appearance of the wide variety of results attributable to SD Suggestion and expectation might best be thought of as experimental variables, valid in their own right, which may or may not be combined with SD in a given study When they are so combined, they may provide the kind of behavioral norm which the subject, adrift in an unprecedentedly amorphous situation, greatly needs, and they may consequently reduce some of the real effects of SD even while they identify the responses the subject should emit Supporting this hypothesis is the statement of Zuckerman (personal communication) indicating that in several experiments where subjects were informed about possible SD effects a day before the session, If anything such information reduced subsequent effects rather than accentuated them

This may indicate the most useful explanation of the role of expectation Suggestion does not necessarily lead to compliance and prophecies are not always self fulfilling But SD itself is an unfamiliar and featureless situation The individual who must cope with it is not only ignorant of

what the successful responses are he is not even sure what success is Any clue whether from previous reading overt suggestion instructional set or intuition provides information and structure This would argue that the important aspect of the suggestion is its information value rather than its content—a hypothesis worth pursuing

THE INFORMATION PROCESSING APPROACH

One theoretical viewpoint which is particularly relevant to SD is that which conceives of the human being as an information processing system The task of the system is to receive stimuli transform or organize them in appropriate ways and use the resulting information to choose adaptive responses A variety of such cognitive theories has been proposed most of which tie in at one point or another with hypotheses about behavioral and/or physiological arousal

The best known application of such an approach to SD is Jerome Bruner s (1961) chapter in the Harvard symposium volume Bruner emphasizes the deleterious affects of SD during a developmental critical period (see chapter 1) He explains these effects by suggesting that to operate effectively in an environment an organism must develop a model of the environment and this for at least two reasons In the first place it is a way of conserving information the means whereby—to use the ancient Aristotelian language—we separate essences from accidents or in modern terms signal from noise Given such models it becomes possible secondly for an organism to extrapolate and interpolate on the basis of partial information to perform the kind of inference that may be called going beyond the information given (p 200) Not only does early deprivation rob the organism of the opportunity of constructing models of the environment it also prevents the development of efficient strategies for evaluating information—for finding out what leads to what and with what likelihood (p 202) Thus according to Bruner the developmentally deprived organism becomes unable to organize stimuli adaptively because it can neither use environmental information nor does it have a cognitive map against which to match the experimental terrain

Short term deprivation in adulthood poses an interference with a maintenance process whereby organisms monitor continuous feedback to guide their responses To put it into one closely related language the TOTE (Test Operate Test Exit) unit (Miller Galanter & Pribram 1960) is disrupted at the second T the individual cannot evaluate the success of his behavior One problem is the decorrelation among the perceptual the motor and the cognitive systems motor behavior is not followed by the accustomed perceptual feedback which could then be interpreted in an accustomed way (for detailed discussions of the importance of normal

motor-sensory feedback, see Held and Freedman, 1963; Freedman, 1964; Held, 1965). Another is that there is no internalized criterion as to what is "successful" behavior in SD, so that it is difficult to evaluate whatever feedback is available. This interference would be quite disturbing, particularly when perceptual or cognitive tasks must be performed; one does have a map, but there is no recognizable landmark against which to orient it. This may be one reason why very familiar tasks, whose critical anchors are well internalized, are not adversely affected by SD (see chapter 5).

Another major contribution to this approach is that of Inglis (1965). In explaining why the interruption of the feedback loop by SD does not result in immediate performance decrements, Inglis hypothesizes that adaptive problem solving and learning provides information which is stored and which the SD subject can use to maintain the loop for a while. Eventually, these referents decay, and then "the oscillations of solution-search might be expected to become wider and wider, and for that matter wilder and wilder" (p. 311). This, although a reasonable hypothesis, implies that problem-solving behavior becomes more original in SD, a prediction not supported by the data (see chapter 5). Inglis explains the SD symptoms of blinded and immobilized patients as a result of reduced storage capacity, which makes these patients even more than normally dependent upon continued patterned input (many of the patients are elderly, and short-term memory is impaired with age). SD is transitorily therapeutic for schizophrenics, and reduces the effects of psychotomimetic drugs, because it interferes with an inefficient feedback mechanism. It serves to filter out excess information which in a normal environment would pass into the system and would disrupt effective behavior (see also Cohen, Rosenbaum, Dobie, & Gottlieb, 1959; Cohen, Luby, Rosenbaum, & Gottlieb, 1960). It is easy enough to assimilate both the findings and the interpretations of SD research to such a framework.

Cameron, Levy, Ban, and Rubenstein (1961) refer to the SD subjects' attempts to maintain structure by reminiscing, moving around, and noticing regular recurrences in this homogeneous world—occurrences such as the faint sound of a scheduled airliner passing overhead, the arrival of meals, and the experimental presentation of inputs (this points to one danger in SD research, the interference of tests with the states that the tests are supposed to measure). Ruff, Levy, and Thaler, in their article (1959), likewise emphasized that "men must . . . have information which means something to them. . . . Without such information, they have no links to their accustomed world. Loss of these bonds leads to anxiety and impairment of performance" (p. 603). In a more recent paper, Ruff, Levy, and Thaler (1961) pointed out that subjects attempt to structure the SD experiment in terms of their accustomed patterns of experience. The work of Rosenzweig and Gardner (1966) indicates that meaningful inputs during SD greatly reduce the occurrence of adverse phenomena. Presumably,

meaningful stimuli help to reestablish the validity of one's model of the world the model which is useless when no external anchors are available

Similarly, the arousal of information drive (Jones, 1966 and chapter 6 of this book) may be based on the need for an intact feedback loop In the same vein Muller (1961) noted that sensory overload must be an excess of *information*, not merely of stimulation Evidence from other research methodologies confirms the importance of perceptual feedback (see e g Smith & Smith 1962 Kohler 1951, Teuber, 1960 Riesen 1958 Held & Freedman 1963) It is reasonable to assume that to the extent that SD does interfere with the feedback loop it will have deleterious effects on performance—at least until adaptation occurs perhaps via the recognition of a new or more subtle set of feedback signals

Freedman (1961) hypothesizes the existence of two schemata which every normal adult organism possesses a spatial schema with such dimensions as up down and self-other which is used to structure the perceptual world and a body schema which is the integrated result of all perceptual and cognitive processes used to locate new sensations and to decide on new actions SD disorganizes the spatial schema and through interaction disrupts the body schema as well The basis of these disruptive effects is that the usual dimensional categories and reference points become inappropriate in SD relationships cease to be continuous and predictable Furthermore there is so much noise in the field (as a result of homogeneous noninformative stimulation and from spontaneous neural firing) that information processing breaks down

Broadbent (1953 1958) has used a computer model of information processing to explain attention learning and memory He views the central nervous system as a single communication channel Because its capacity is limited a selection process takes place in which certain characteristics make a given stimulus more likely to be attended to some of these characteristics are stimulus features (physical intensity modality etc) some are environmental (e g time since the last information from similar events was processed) and some are organismic (drive states which increase attention to reinforcers) The filtering system passes and blocks different kinds of information as time goes on thus if only one kind of stimulation is presented externally attention tends to wander The subject becomes attuned to his own thoughts emotions and daydreams, and to faint residual stimuli in the environment These distractions become more and more potent as time goes by and although Broadbent applies the explanation primarily to vigilance studies we understand the occurence of hallucinations inability to concentrate lowered sensory thresholds and other SD data

One implication of the information processing approach is that personality differences in the reaction to SD can be predicted systematically Basically one would expect that those who rely too strongly on external

cues to maintain psychological equilibrium do poorly' (Ruff, Levy, & Thaler, 1959, p 603) On this basis we would expect concepts such as introversion-extraversion, satiability, conceptual complexity, stimulus seeking, and the like, to provide predictive frameworks There is some evidence in favor of such hypotheses although it is by no means conclusive (see chapter 12)

One personality theory which predicts differences in the reaction to SD is that of Schroder and his co-workers (Harvey, Hunt, & Schroder, 1961, Schroder, Driver, & Streufert, 1967) This theory posits a dimension of conceptual simplicity-complexity The conceptually simple individual processes information in rigid, absolutistic ways whereas the complex person is flexible, integrative, and subtle At the same time, he is able to process information more accurately and more rapidly, and has a relatively high need to obtain and use information—rather than existing preferences or biases—in coping with problems In the three SD studies based on this framework, complex people were shown (1) to find SD more unpleasant than simple subjects (Suedfeld, 1964a), (2) to be less persuasible, both after SD and in a control condition, than simple subjects (Suedfeld 1964d), and (3) to be more willing to comply with the demands of the experiment in order to receive information, but to be less willing to accompany compliance with actual belief change, than either control subjects or than confined simple subjects (Suedfeld & Vernon, 1966)

Field dependence-independence which is related to conceptual complexity (see Harvey, Hunt, & Schroder, 1961), has also been found to influence the response to SD Field-dependent subjects may be more stressed by SD (Culver, Cohen Silverman & Shmavonian, 1964, no such difference was found by Biase & Zuckerman, 1967) but their performance on various perceptual tests although consistently worse than that of field independents was no worse after SD than it had been before (Cohen & Silverman, 1963) The importance of informational anchors was demonstrated by the fact that when subjects were told ahead of time what the experience would be like, field-dependent participants reacted with much less anxiety and arousal—in fact, their responses were much like those of the field independent subjects (Culver, Cohen, Silverman, & Shmavonian, 1964) Similarly, Murphy (1966) reported a significant SD-caused cognitive decrement for field-dependent but not for field independent subjects Both groups evidenced decrements when suggestions indicated that deterioration was to be expected

We may thus conclude that the difference between the groups in the no-information condition was due to differential levels of tolerance for lack of external structure Presumably field independent people can generate enough information internally to ward off highly negative reactions to SD (see chapter 12 for a more detailed review of these studies) This, like the discussion of conceptual complexity, provides a more general

alternative to the expectation suggestibility hypothesis advanced earlier That is conceptually simple people and field-dependent people have relatively strong needs for external clues one result of this fact is that they are more suggestible when the availability of clues is low There is an inverse relationship between the amount of information in the environment and reliance upon any particular item of information Such an explanation treats personality differences in susceptibility to set or expectation on the part of SD subjects as a subclass of broader differences in information processing characteristics

An interesting reversal of focus was provided by Jacobson s (1966) study in which he demonstrated that a one hour SD session increased field independence! Unfortunately Jacobson did not separate the data from originally independent and dependent subjects the pre post differences he found are fascinating but one wonders how the original scores were related to the change scores The importance of the choice of instruments is also shown by this study Heron (1961) using the Embedded Figures Test found no difference due to PD while Jacobson did find one on the Rod and Frame Test (where bodily not merely visual cues can be used)

There has also been some theorizing that extroverts, relying more upon external cues respond less adaptively to SD than do introverts The evidence on this point is quite contradictory introverts quit sooner but obey instructions by moving less (Tranel 1962) extroverts report more cognitive disturbance while introversion is negatively correlated with hostility heart rate variability and changes in GSR fluctuation (Zuckerman et al 1966) extroverts underestimate time spent in SD more than introverts (Reed & Kenna 1964) and there is no difference between the two groups in movement or in SD tolerance (a failure to replicate Tranel s results) visual sensations or changes in subjective well being as a result of SD (Rossi & Solomon 1966)

The theories which emphasize the information reducing aspects of SD have several great advantages For one thing they explain why PD—where the sensory receptors certainly do not suffer lack of stimulation—has effects comparable to and sometimes even more severe than SD For another they integrate SD theory into more established and more general explanations of behavior particularly consistency and variety theories (see Fiske & Maddi 1961b Maddi 1967 Berlyne 1966) For a third (and many people would argue that this is no advantage) they focus the primary concern of behavioral scientists where it belongs on behavior and on psychological explanations thereof Lewin s idea that psychological phenomena should be explained on the basis of psychological concepts has much to recommend it and to explain such phenomena by referring to vaguely understood physiological concepts seems a waste (If we must have vaguely understood substrata they might as well be psychological ones!) Inglis (1965) attack on the reticular system explanations of SD puts this point

clearly: "It is . . . trite to say that the nervous system, or any part of it, is complex enough, if only we understood its complexities, to account for behaviour . . . In fact, unless and until these very neural complexities are themselves understood, it is difficult to see how such physiological mysteries can be used for the elucidation of behavioural puzzles" (p. 309). This is not to say that there is no relevant neurological substratum; to argue that, we would have to believe in a transcendental psyche. But to the extent that the neurological explanations are based on guesses, they offer no advantage over psychological guesses—and in fact, being one more step removed from the behavioral data, may offer a disadvantage (see also Hebb, 1958; 1966; Reitman, 1965, p. 43).

COGNITIVE MOTIVATION: THE U-BIQUITOUS CURVE

Another aspect of information deprivation is its motivational power. Deprivation implies the removal of a desired and/or needed class of objects, and a consequent tendency to regain those objects. The adaptation of classical drive theory to SD has been discussed by Jones (chapter 6); briefly, the list of drives is extended so that it contains needs for exploration (Butler & Harlow, 1957), manipulation (Harlow, 1953), competence (White, 1959), novelty (Maddi, Charlens, Maddi, & Smith, 1962), information (Jones, chapter 6), variation (Maddi, 1961), stimulation (Lilly, 1956), etc. These "drives" are then used as constructs analogous to those of the homeostatic biological drives such as hunger and thirst. Hullian and related behavioristic theories can be called upon to deal with specific and general drive effects, with the parameters of deprivation duration, reinforcement, conditioning, and the like.

Besides the motivational aspects of information, uncertainty, and novelty, we have models which relate the effects of SD and/or isolation to more traditional motives aroused by the situation. These motive states have been hypothesized to include frustration (Hartup & Himeno, 1959), anxiety (Walters & Ray, 1960), social drive (Gewirtz & Baer, 1958), dependency (Azima, Vispo, & Cramer-Azima, 1961), and stress in general (Shmavonian, 1964). All of them have in common the characteristic of Hull's "D" and Hebb's "arousal function": the increase of arousal, with predictable effects on emotion and performance (see Walters & Henning, 1961; Bandura & Walters, 1963; chapter 5 of this book).

The drive approach has the attraction of integrating the effects of isolation, confinement, and SD into a well-established theoretical system. On the other hand, it tends to erode the once-vital physiological aspect of the definition of drive, because no relevant tissue deficit has been identified with exploration and the other "new" drives. Furthermore, there seem to be greater intraspecies differences in the need for novelty, as an ex-

ample than in the need for food reinforcers vary more widely and are difficult to identify independently adaptation seems to occur much more easily and whereas the traditional drives usually need external reducers novelty and stimulation can be produced internally Last the extensive evidence for drive inducing motivation goes counter to the mainstream of traditional drive-reduction theory although there is of course a great deal of evidence that organisms seek the arousal of even the homeostatic drives under certain conditions (e g Sheffield 1954 Mendelson 1967) Obviously it is possible to stretch the drive definition to cover these motives The gain provided by doing this is questionable and definitional quibbles are a rather sterile enterprise

Another perhaps more fruitful point of view has led to the proposal of formulations which are closely tied to information processing theory and to drive theory (particularly to the concept of general drive state) as well as to physiological arousal theory

These are the formulations which use a concept of psychological arousal to explain SD effects On the one hand these explanations use arousal or activation as the basic construct on the other they use non physiological measures for inferring arousal level (see e g Blum Geiwitz & Stewart 1967) In general their predictions follow the ubiquitous U-curve when arousal is moderate performance is optimal

Fiske and Maddi (1961a) have proposed a conceptual framework which although it refers to such neurophysiological constructs as activation (central) and arousal (peripheral) rests primarily upon behavioral evidence The activating effect or impact of stimulation depends upon its intensity meaningfulness and variation The theorists posit an optimal activation level the organism taking action to restore this level whenever necessary Because level of activation varies directly with the total impact of current stimulation one would expect that high or low impact would result in optimum seeking This is the familiar hypothesis of the golden mean and Fiske and Maddi accept the curvilinear activation performance relationship which is defended by Schlosberg (1954) Hebb (1955) Leuba (1955) Duffy (1962) Malmo (e g 1959) and Easterbrook (1959) among recent theorists and whose original foundation stone was the Yerkes-Dodson Law (1908) The Fiske and Maddi (1961b) book integrates into this framework findings from restricted rearing studies observations of exploratory and play behavior in animals human motivation research personality research and even psychological aesthetics A discussion of human vigilance and SD studies is also included (Fiske 1961) The reviewer points out the great individual differences in response to SD and hypothesizes that these are due to differential ability to maintain the optimal activation level Obviously external stimulation in SD provides low impact at least after adaptation but the subject can stimulate himself or become more sensitized to residual stimulation thus increasing activation

Maddi (Maddi Charlens Maddi, & Smith, 1962, Maddi & Berne, 1964, Maddi, Propst & Feldinger, 1965 Maddi & Andrews 1967, Maddi, 1967) has gone on to document and to measure a need for variety This need has two forms active measured by the novelty of responses to an unstructured situation and passive, desire for novelty, scored similarly to the TAT type 'nAch measure (Atkinson 1958) The former has been found to decrease, and the latter to increase in a monotonous situation Maddi and Berne (1964) hypothesized that subjects could not engage in active variation production without rejecting the constraints of the experiment and that the continued monotony then interfered with cognitive activity Thus need for variety was expressed only passively It is strange that no SD researcher has yet used Maddi s measures and hypotheses in spite of their obvious relevance

Jones (see chapter 6) demonstrates that an information need arises in SD, the deprived subject is motivated to restore an optimal level of information in his environment Although Jones is essentially a drive theorist, the fact that this optimal level is a moderate one is implied by the aversiveness of highly informational stimuli for subjects who have been information satiated or overloaded This theory and the related research are extremely important contributions, their cursory treatment here is justified only by their detailed exposition in chapter 6

Berlyne (e g, 1966) uses exploratory behavior to show the attractiveness of both structure and uncertainty Specific exploration occurs when the organism is disturbed by excessive uncertainty, its goal is to get stimulation from sources that can supply the specific information needed 'Diversive exploration occurs when the organism seeks out change, novelty, complexity, regardless of source in order to reduce its arousal level to optimal The kind of information seeking discussed by Jones along with the need for stimulation found by the McGill group by Vernon and McGill (1960) by Zuckerman and Haber (1965) by Goldstein (1965) and by Smith and Myers (1966) the stimulus-action hunger defined by Lilly (1956) and the like represent diversive exploration, the action taken by SD subjects to cope with this unstructured and normless situation (see, e g., Vernon 1963 pp 67–70) is specific exploration Considerable evidence exists for similar optima in lower organisms (see chapter 1, Fiske & Maddi 1961b Isaac, 1962 Berlyne 1966 Harrington & Kohler, 1966)

Thus in Berlyne s theory exploration has two functions to reduce uncertainty and to increase stimulation Quite clearly a moderate level of uncertainty is best This is similar to Maddi s recent stand (1967) in which he concludes that both consistency and variety are desired—in fact "pursued and enjoyed

The most recent entrant into the field is Zuckerman s Optimal Level of Stimulation concept, described in detail in chapter 12 The major postulates include a positive relationship between level of arousal and stimulus variables (these latter however can vary inversely among themselves

making prediction difficult) an inverse relationship between existing level of arousal and the arousal potential of stimulation characteristic optimal levels for every individual the independence of cortical and autonomic arousal and the optimality of moderate arousal levels This formulation is in many ways similar to other U curve theories Its major advantage is that it is much more specific than most taking into account such seldom considered variables as diurnal cycles Of course it is also more closely tied to SD research than the more general theories and integrates some aspects of other SD models (e g the concept of primary process tolerance)

Some of these theories seem to deemphasize the specific characteristics of SD in order to integrate the technique into a great array of other situations just as the expectation suggestion set theories do In a way this is good the common view of SD among psychologists is that it has very little relevance to the rest of the experimental areas One sign of this is that even now most introductory texts if they mention SD at all restrict their discussion of the topic to the more dramatic and *outré* of the McGill findings At the same time many SD researchers tend to overlook important connections between their own work and relevant research in animal behavior developmental psychology human motivation etc Of course although SD may—in fact must—have many features in common with other situations, it is also important to remember its unique characteristics No completely adequate theory will be developed until both of these aspects are integrated

U curve theories have major advantages in that they tend to be empirically testable have at least some relationship to neurophysiological facts while maintaining focus on behavior and provide a fairly general framework They have two major drawbacks besides the one of identifying the relevant physiological indices and effects First arousal level (or emotional level or level of information need) is at the moment impossible to measure precisely For this reason no attention is paid to the probability of constant fluctuations in arousal even within a given experimental session Most experimenters rely on a crude ordinal scale in which low moderate and high levels are defined operationally within the specific experimental manipulation Because one experimenter s moderate level may be another s high [e g Suedfeld Glucksberg and Vernon s (1967) moderate arousal—SD only—condition would be the high arousal treatment in the usual SD study] quite obviously generalization is very tenuous Another methodological weakness is that arousal levels which are actually responses are usually defined in terms of stimuli This procedure erases all individual differences in actual arousal failures to respond to the experimental variable overreactions to the experimental variable and all intervening degrees of response are combined into one category

Second optimal arousal level is never adequately defined It is often stated that optimum varies with personality and with task (Fiske & Maddi 1961b) but little work has been done to measure the differences

associated with these factors Extremely high and extremely low arousal are supposed to be aversive, yet some people engage in Grand Prix racing, and others seek meditation in solitude—and we cannot predict who will behave in which way Even worse, the definition of "optimum" is inexact Some theorists define it as the chronic (accustomed) arousal level, assuming that the range of levels experienced by the organism during development becomes optimal for that organism, others define it more or less operationally as the level which the organism prefers, measured by approach avoidance (or diversive exploratory) behavior, still others think of it as the level at which performance efficiency is at its highest There is no reason to think that these three definitions, or any two of them, will identify the same level as the optimal one, yet theorists and experimenters blithely ignore the problem Not only that, but there may be a great number of optimal levels however defined, varying with tasks, personality characteristics, moods, situations, etc

CONCLUSION

The theoretical approaches reviewed in this chapter differ from those of chapter 12 in that they use less physiological yet very new constructs The concern with the role of the experimenter and related sources of expectation is currently a burning issue not only among SD researchers, but throughout psychology It is unfortunate that expectation propositions tend to arouse defensiveness and to be summarily rejected by many workers, unfortunate because they represent both interesting variables in their own right and contaminants against which one should be on guard They can be, and should be, integrated into any theory which purports to explain SD phenomena

The information processing approach and its U-curve variant apply to SD the most recent advances in neurophysiological and psychological research on motivation cognition development, and personality Springing from the invention of electronic computers they construct a computer model of human behavior Although probably no more 'real than Freudian steam-engine models or S-R telephone switchboard models they nevertheless offer a fruitful way to analyze the complex and dynamic interaction between organism and environment

One can no longer say that SD has facts but no theory Rather, many theories can be invoked each of which explains some of the data To the extent that these theories and bits of theories integrate SD related facts with general behavioral facts this is to the good but as Zuckerman points out in chapter 12 what we need now is a discriminating search for specific kinds of facts—those which will enable us to identify the most useful and relevant theories

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In order to increase the usefulness of this volume as a reference source a supplementary bibliography has been added This bibliography consists of articles on sensory deprivation not cited in any of the chapters those appearing since the completion of the manuscript and finally a representative sample of articles on topics indirectly related to sensory deprivation e g surgical deafferentation monotony imprisonment effects of early sensory restriction and maternal and cultural deprivation (see Šváb & Gross 1966 and Weinstein *et al* 1968 for a comprehensive bibliography on these latter topics)

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